STUDIES IN SCIENCE

PATTERSON

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STUDIES IN SCIENCE

FOR

SEVENTH AND EIGHTH GRADES

AND

JUNIOR HIGH SCHOOLS

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CHICAGO NEW YORK

ROW, PETERSON AND COMPANY

PREFACE

This book is designed for the seventh and eighth grades of rural and village schools, and for the first book in science in Junior High Schools. Its purpose is to stimulate interest in the simple scientific problems found in daily life, to train toward a correct understanding and truthful interpretation of common objects and phenomena, and to arouse some appreciation of the intimate relation that exists, on the one hand, between science and health, and, on the other, between science and economic prosperity.

The work has grown out of a conscious effort to fit science study to the needs and interests of grammar school children. All the exercises have been used in regular class work in the training school of the Illinois State Normal University. They represent much sifting, rejection, and rearrangement during a period of about ten years. Most of them have had the additional test of the class-room in elementary schools where teachers have used "Outline Lessons in Nature-Study Agriculture," published by the author five years ago.

The material is chosen from the immediate environment of the pupils: the home, school, farm, and garden. It is sufficiently agricultural in character to warrant the use of the book as a text in elementary agriculture. While some attention has been given to continuity of subject-matter, the chapters in the main are arranged with reference to seasonal, rather than logical, sequence; biological topics occurring in the fall and spring, physical topics in the winter.

Part One deals largely with the habits, structure, and uses of domesticated plants, and is followed during the winter by a study of soil and soil-water in their relation to plant growth. In the spring a number of practical farm and garden projects are planned, accompanied by definite scientific studies that look toward some realization of the basic principles and fundamental laws that govern plant life.

Part Two emphasizes, in its biological phases, animal life and projects, but takes up also some of the lower plant forms, and the more difficult problems of plant propagation. The physical studies during the winter are based upon water supply, heating, lighting and ventilating the home and school. In the spring, simple problems of landscape gardening are introduced.

In order to use the book successfully, teachers should realize that pupils must have a hand-to-hand contact with real objects and phenomena, must deal with actual situations, must come naturally to one problem after another. The lessons aim to suggest problems, to direct observation, investigation, and experiment along lines that foster openmindedness, promote initiative, and lead to independent effort in the discovery of truth. The discussions and explanations accompanying each study are designed to clear up doubts concerning the more difficult problems and to state facts that may not be found at first hand.

The author wishes to express her gratitude to the teachers and pupils of the training school in the Illinois State Normal University who made possible the practical working out of these studies in science. Special thanks are due to Mr. Fred Ullrich, Miss Agnes Storie, and Mr. George Cade, for their valuable assistance in testing various phases of the work, and for their interest and advice in the attempt to meet the needs of the boys and girls.

The author wishes also to acknowledge her indebtedness to Miss Ruby Scott for her careful proof reading, to Miss Evalyn Clark, Miss Frances Augustine, and Mr. Harold F. James for assisting in the preparation of the original illustrations; and to those publishers who have permitted the use of their illustrations.

ALICE JEAN PATTERSON.

TABLE OF CONTENTS

PART ONE

PART TWO

CONTENTS

STUDIES IN SCIENCE

PART ONE

FALL STUDIES

CHAPTER I

PLANT STUDIES

Plants are among the most important objects in your environment. They not only add much to the beauty and comfort of your surroundings, but they feed and clothe the world. Everything that you eat, if you omit water and certain minerals that it contains, may be traced directly or indirectly to plants. The same thing may be said about your clothing. Much of the raw material of which it is made comes directly from plants, while the rest is provided by animals that depend upon plants for their food.

Plants are not only important because of what they directly provide, but through them a large proportion of the men and women all over the world earn a livelihood. Some of you are even now directly interested in gardening or farming. Your garden and farm pro-

jects, however, will not have their full educative value unless, along with the practical work, you study the plants themselves to find out all you can about their habits of growth, their relation to the soil, their work and their uses.

1. Vegetables

Material. Vegetables raised in the district. Special types—tomato, squash and pumpkin, potato and sweet potato.

Study. Make a list of all the different kinds of vegetables that have been grown in your neighborhood this season. Classify them with reference to the time they are ready for use:

1. Spring.
2. Early summer.
3. Late summer.
4. Fall.

Which ones continue to supply food for the longest period without replanting? Which are in greatest demand on the market? Which are used most frequently on your home table?

The tomato. Observe tomato plants and note their habit of growth. What is the position of the stems of an unsupported plant? Describe the leaves. They resemble the leaves of what other garden

plants? For how long a period does the tomato plant blossom and bear fruit? Look for all stages from the unopened flower bud to the mature fruit.

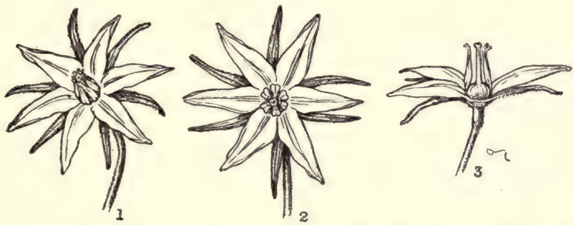


Fig. 1. 1. A tomato flower showing the slender sepals below and the six-pointed corolla with the stamens clustered at the center. 2. Flower with stamens removed showing the pistil in the center. The round part of the pistil is the ovary. 3. A flower from which the corolla has dropped. The withered stamens and style are still fastened to the growing ovary.

Examine a flower, and name and describe its parts. If you do not know the names, find them in Fig. 1. Compare a number of flowers and determine in what respects they vary. What parts of the flowers fade and drop off? What parts remain and produce fruit?

Make cross-sections of several green tomatoes and also of a ripe one. How many seed cells or sections do you find? Where and how are the seeds fastened? Compare the fruit of different varieties as to the amount of meat and seeds. Look for differences among individual plants of the same variety as to the number and size of the tomatoes and

the quality of the fruit. Choose for seed those that have the characteristics you wish to reproduce next year.

Name all the ways that tomatoes are used for food. How are they preserved for future use? How important are they as an industrial plant?

Discussion. In your study of the flowers you probably found quite a difference among individuals in the number of se′ pals, pĕt′ als and stā′ mens. Some of them look as if they were a combination of several flowers. This, no doubt, has come about by cultivation. Botanists tell us that the flower of the wild plant is simple and that the fruit does not have so many sections. The fruit is an excellent example of a berry. It is the ripened ō′ va ry.

Tomatoes are fast becoming important industrial plants. They are grown in almost every state in the union. In many places large tracts of land are given over to their culture. They are canned in large quantities in canning factories as well as by girls' clubs and in the home. Quantities are also used every year in factories to make catsup, pickles and soup preparations.

History. The tomato is a native of the warm regions of South America. It was taken to Europe during the sixteenth century, but was not used for food until much later. In United States it was

raised as a curiosity or ornamental plant known as the "love apple" until about 1830. It then began to be used on the table; but its true food value has been recognized only about fifty years.

Description. The stem is weak and when unsupported trails upon the ground. You probably found flowers, the small green berry, the larger one and the ripe fruit on the same plant. This is one of the great advantages of the tomato plant, since it continues to blossom and bear fruit until frost kills the plant. The leaves are compound, and they, as well as the flowers, are similar to those of the potato. These plants both belong to the Nightshade family.

Canning tomatoes. If you have never canned any fruit, nothing is easier to begin with than tomatoes. For directions see Harvesting and Canning, page 150.

The Squash and Other Cucurbits

Material. Growing plants of squash, pumpkin and other relatives as melons and cucumbers.

Study. No garden plant has more interesting characteristics and habits than the squash and its relatives. Observe one of the growing plants. How much space does it occupy? What is the length of the longest branch? Look down upon the plant and determine

to what extent the leaves hide the ground. What special adaptations can you find that make it possible for all the leaves to be exposed to the light? Cut a stem in two and describe its structure. What do you find on the stem besides leaves? Describe a tendril. Where are the tendrils attached? What is the use of the tendrils?

Fig. 2. Portion of a squash plant showing the relation of leaves and tendrils.

Look for flowers. How many kinds do you find? Examine the two kinds carefully, stating how they are alike and how different. Try to make out the special function of each flower. Observe the flowers in the evening. What do they do?

What insects have you found visiting the flow-

ers? Look for the place where the nectar is secreted.

Cut a small green pumpkin or squash across the center. How many distinct sections has it? To what are the seeds attached? Cut a ripe one and note the changes that have taken place. Compare a section of a cucumber with the pumpkin noting resemblances and differences.

Discussion. The pumpkin, squash, cucumber, melon and gourd belong to a family known as *Cucurbitacae*. They are often called cucurbits. The entire family is noted for the wonderful growth that the plants make in a few weeks or months. They produce not only long vines and large leaves, but great numbers of large fruit. While these plants have the habit of trailing upon the ground, some of them are good climbers. The gourd is an example. All of them have tendrils which seems to indicate that perhaps some time in their past history they were all good climbers. Why would some of them not do well as climbers now?

History. The history of squashes and pumpkins is interesting. Botanists believe that originally they were natives of Asia. Nevertheless, the North American Indians raised them in their fields of maize long before the early colonists settled in America.

You will find it worth while to make a comparative study of any other cucurbits that may be found

in your neighborhood, as watermelons, muskmelons and cucumbers. All of these are of Asiatic origin. They were first brought over into Europe and from there to America. The melons thrive best in the South where they have a warm soil and climate.

Description. You found two kinds of flowers, each with a five-lobed yellow cō rŏl′ la and five slender green sepals. The one with the peculiar body in the center resembling a yellow candle is a stam′ ĭ nāte flower. If you rub your finger over this body, you find it is covered with pŏl′ len. It is made up of the stamens. At the lower part of this you find some slits which open into a shallow cup. In this is the nectar which attracts bees. This flower is called staminate because it has stamens and no pĭs′ tĭl.

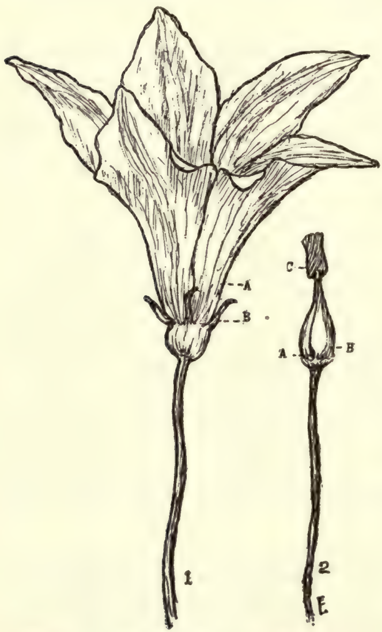


Fig. 3. 1. Staminate flower of a squash. A, Corolla; B, One sepal (Five of these form the calyx); 2. Staminate flower with corolla and calyx removed to show the stamens. A, Opening into nectar cup; B, Filament; C, Anthers joined to form a knob.

The other flower with the cā′ lyx and corolla fastened to the top of a green body which later becomes the fruit is the pĭs′ tĭl lāte flower. Inside the corolla you find the pistil with three short styles each with a stĭg′ ma at the top. The green part below is the ovary. This flower also has a nectar cup situated just below the styles. Both flowers are necessary to produce the seeds, since neither has all the essential organs.

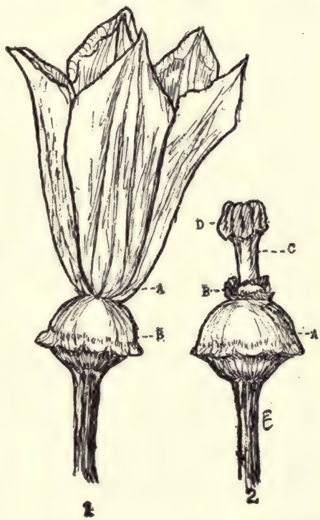


Fig. 4. **1. Pistillate flower of squash.** A, Corolla; B, Ovary which develops into squash. 2. Pistillate flower with corolla removed to show pistil. A, Ovary; B, Nectar cup; C, Style; D. Stigma.

Bees are usually the carriers of pollen from the staminate to the pistillate flowers. As the bee enters the opening to get nectar its legs and body become dusted with pollen. When it goes to a pistillate flower it is almost certain to brush against the stigmas and leave some pollen. It is the pistillate flower that always produces the fruit and seeds. In the cross-section of the green fruit you found three curved partitions to which the seeds are attached. Later the pulp changes to stringy coarse

fibers which allow the ripe seeds to drop out in a mass.

There are a large number of varieties of squash and pumpkin.

The hard-shelled squashes and a few pumpkins may be kept fresh for winter use if they are gathered before being frozen and stored in a cool place. They may be successfully canned by the hot water or steam process. Besides their use as human food, pumpkins are used largely as food for cattle.

Potatoes. Are potatoes in your community raised as farm or garden crops? Are they early or late varieties? At what time are they ready for use? What is the condition of the plants of early potatoes at this season? Of late potatoes?

Study. Examine plants that are still green. What is the position of the stems? Describe the leaves. If there are any flowers find their parts. If they have all faded, see if you can discover where they were attached to the stems. Look for fruit. How do you account for the fact that potatoes blossom and yet rarely produce fruit and seeds?

Carefully remove the soil from a hill. How near the surface are the potatoes or tubers? How far from the center of the hill? Are the roots above or below the tubers? How are the tubers fastened to the main stem? Dig several hills and compare as

to the number of tubers and uniformity of size. Which hills would you prefer to use as "seed potatoes" next year?

If possible, compare different varieties of potatoes and note differences in color, shape, smoothness of skin, number and depth of eyes. Which do you consider preferable for family use? Which may be peeled with the least waste? Do you find scab, rough blotches, on any of the potatoes? What causes scab?

What methods of harvesting potatoes are employed in your district? Find, if possible, what the yield is per acre. What is a good average yield? What is the current price per bushel? What do you think of potatoes as a paying crop? Which takes the greater amount of labor, the raising of a crop of corn or a crop of potatoes? Which yields the greater profit?

Name all the uses of potatoes that you know; all the different ways of cooking. How are they stored and kept for future use? See Home Projects, p. 159.

Discussion. The potato is among our most valuable garden and farm crops. It is probably used more extensively as food the world over than any other crop except rice. In the northern states it is an important farm crop; in most other states it is raised as a truck or garden crop.

History. The potato is a native of America. It was probably found in South America and Mexico by the early Spanish explorers, who introduced it into Europe. It was soon grown in a number of the European countries. It became so important a crop in Ireland that the name Irish potato was given to it. The early colonists from Europe brought it over into Virginia and New England. It has been greatly improved by cultivation and selection. Great numbers of new varieties have been produced. The wild potato is still found in Chili and Peru. The tubers of this wild plant are very small, not larger than small marbles. The flowers are abundant and most of them produce fruit and seeds.

Description. The plant is weak and trailing, a relative of the tomato, which it resembles in leaves, flowers and fruit. You have noticed that while the potato has flowers it seldom produces fruit. This habit is probably brought about by cultivation. The food the plant consumes is used to produce large tubers instead of fruit and seeds. The fruit is a small green ball resembling a small tomato.

You will be interested to know that seeds are used to produce new varieties. If you should plant potato seeds you would get a large number of different kinds of potatoes. Most of them would probably be of little value, but among them you might

find one of such excellent qualities that it would be well worth growing. You could give it a name and after several years when you had grown a large quantity put it on the market as a new variety. That is just what potato breeders have done to produce the different kinds of potatoes.

Instead of seeds, the tuber is used to propagate new plants. Much may be done to improve the potato crop both in quantity and quality by a careful selection of tubers for planting. You noticed in comparing the hills that some produce a larger number of fair-sized potatoes than others. These are the ones that should be chosen to plant next spring.

Potatoes are used chiefly as food for the table. They are also used largely in some places for making starch. They are very nutritious when properly cooked. Baked potatoes are more wholesome than those cooked in any other way. Another method is to boil the potatoes with the skins on. In both these methods certain healthful minerals are retained.

Potatoes yield on an average about one hundred bushels per acre. Some tracts yield two or three times that quantity. The estimated cost of raising an acre of potatoes is between twenty-five and forty dollars. You can easily calculate the net profit.

Sweet potatoes. To what extent are sweet potatoes raised in your community? What is the habit

of growth of the plant? How many branches grow outward from one plant? What is the length of one stem? Describe the leaves. Compare a number of leaves and note variation in shape of blade and length of pĕt′ i ōle.

Study. Dig up a plant and observe how the roots are attached to the stem. How many potatoes does one plant produce? Get the average of several hills. How greatly do the potatoes in one hill vary in size? Compare a sweet and a white potato, noting differences.

Look for flowers. Where are they attached to the vine? Study the parts. Find the seed pods. How many sections in each? How many seeds? What common flowering plant do the flowers, leaves and seeds resemble?

At what time are the potatoes harvested? What is the yield? How valuable is the crop? What is the current price per barrel or bushel? How are potatoes stored for future use? What is the history of the sweet potato?

Discussion. The sweet potato is a near relative of the morning-glory. You probably noticed the similarity in the shape of the leaves. The flowers, too, resemble those of the morning-glory. However, in the North flowers are rarely produced. In the South they are common. They are purplish pink

in color and the corolla is from one to two inches across. The ovary ripens into a four-celled pod very much like that of the morning-glory. There is one seed in each cell.

History. The sweet potato stands next to the Irish potato as an important garden crop in United States. It is the chief garden crop in the South. Certain varieties do well in some of the northern states. New Jersey is especially noted for its fine sweet potatoes.

The native home of the sweet potato is not definitely known, but botanists believe that it originated in tropical America. It reaches its highest development there, where it is a perennial, living year after year producing its roots and seeds each year.

Description. The sweet potato is a fleshy root, while the white or Irish potato is a tuber, a kind of underground stem. Small branch roots grow from the ends and sides of the sweet potato, but there are no eyes or buds as there are on the white potato. The fleshy roots are used to propagate the plants. They are planted early in the season in a hotbed. They send out a large number of sprouts. These are pulled off and set about eighteen inches apart in ridges that have been prepared for them. Some growers set out a few plants and when these have grown stems eight or ten inches long the ends are cut off and set out, thus producing new plants.

2. Flowering Plants

Material. Flowering plants of the neighborhood. Choose for study several annuals that have single flowers, as petunia, nasturtium, California poppy, sweet pea, snapdragon or larkspur. Note the habit of growth, the characteristics of the stem and the leaves.

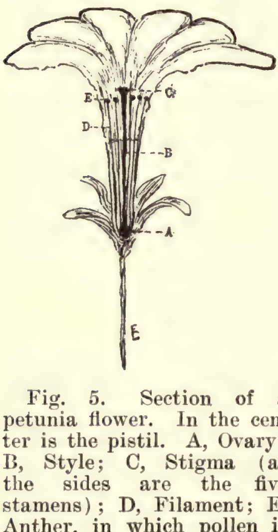


Fig. 5. Section of a petunia flower. In the center is the pistil. A, Ovary; B, Style; C, Stigma (at the sides are the five stamens); D, Filament; E, Anther, in which pollen is produced.

Study. Examine a flower. What different organs do you find? What are their names? See Fig. 5.

What is the function of a flower? What parts are necessary in order that seeds may be formed? Look for pollen on the anthers. Where must the pollen be placed in order to be of use in forming seeds? Find flowers in various stages of development from those that have just opened to those that are fading. What parts wither and drop off? What ones remain? What develop into fruit and seeds? Study the fruit in its stages of growth.

What insects do you find on your flowers? Watch patiently to discover what they are doing. Determine, if possible, where the nectar is secreted and

to what extent insects must become dusted with pollen in order to obtain it.

The following outline will be found helpful in the study of flowering plants.

1. Name:

2. Habit of growth:—erect, procumbent, climbing, creeping.

3. Stem:—tall, low, branching, spreading, smooth, hairy, sticky, etc.

4. Leaves:—simple, compound, large, small, hairy, soft, rough, special characteristics that make them attractive.

5. Flower:—a. single, cluster; b. dates of flowering; c. simple description of parts; d. special features. Where is the nectar secreted? Insects that visit the flower.

6. Fruit:—a. kinds; pod, capsule, berry, pappus flyer, etc.; b. seeds:—few, many, large, small, special adaptions for distribution.

7. Remarks:—history, family relationship, value for ornamental purposes.

Filled out for the petunia, the outline will appear in your notebooks as follows:

1. Name: Petunia.

2. Habit of growth:—procumbent and spreading with many erect branches.

3. Stem:—hairy and sticky.

4. Leaves:—simple, vary in size, hairy, sticky, thick.

5. Flower:—a. simple; b. dates of flowering, from June until frost; c. calyx, green, five sepals; corolla, white, purple, or pink, funnel shape, long tube; stamens, five fastened to the tube of the corolla; pistil, one in center with large green ovary, slender style and disk-like stigma; d. nectar is secreted at the base of the corolla tube. Moths and butterflies visit the flowers to get nectar. All parts of the flower wither and fall off except the calyx and ovary.

6. Fruit:—a. formed from ovary, a conical pod or capsul. b. seeds, many and small; pod splits at top and seeds fall out.

7. History, etc.: The petunia that we know has been produced by the mixing of two species that are natives of South America. One of these had a large white flower, the other a small, reddish purple one. The two species were introduced into Europe some

time between 1823 and 1832, and it is from the mixing of these that we get the different colors that petunias show today.

The petunia belongs to the Nightshade family; hence is a relative of tomatoes and potatoes.

In a similar way fill out the outline for other flowering plants. You will find some interesting differences among them. For example, the nasturtium has its nectar secreted in a long spur which is formed from three of the sepals. It has very prominent streaks on the petals which lead down to the nectar. These are called nectar guides.

The California poppy has its sepals in the form of a green cap which encloses the flower bud. This cap falls off when the flower opens and nothing is left but the little frill to which it was fastened.

The sweet pea has three differently shaped petals in each flower. It is known to botanists as the butterfly flower. Each kind of petal has a name; the broad one at the top is the banner, the side ones are the wings, and the two that are joined together to hold the stamens and the pistil form the keel. Our common beans and peas, the different kinds of clover, locust and red bud trees all have this same kind of flower. The fruit also is similar, a flat pod with seeds on the inside. The pod is called a legume.

Composite flowers. After you have studied several simple flowers, choose one that has a large number of small flowers crowded together into a head, such as a sunflower, cosmos or gaillardia.

Examine a sunflower or other head. How many different kinds of flowers do you find? How do the little flowers, or florets, in the center differ from those at the outside? Choose for close observation one of the florets that has two thread-like bodies projecting from the top and ending in a curl. Find all the parts of the flower. How many points has the brownish

corolla? How many sides has the brown tube at the center. Open up the tube with a pin and see what is on the inside. What are the two curled over threads at the top? To get the names study Fig. 7. What part will produce the seed? Break a head through the center so that you may better see the arrangement of the florets. Describe the little bodies that you see sticking up at the base of each little flower.

Which florets open first? If possible watch a head for a number of days to solve this problem. Examine closely one of the outside flowers. What parts does it lack? Does it produce seed?

Study a head that has gone to seed. What parts of the florets are left? Count the seeds. What use is made of sunflower seeds? How valuable are they?

Discussion. The sunflower is an excellent type of a large group of flowering plants both wild and cultivated that have a great number of small flowers crowded into a head. All such plants belong to the family *Compositae.* We usually speak of the flowers as composites.

Look for other composites among your flowering plants. You will find some interesting differences among them. The zinnia and asters have well developed styles and stigmas in their ray flowers, so they produce seeds as well as the disk flowers. The bracts

in these flowers are fringy and colored and add no little beauty to the flowering head.

Make a collection of all the composites among your cultivated flowers.

Sunflowers are of considerable value in certain states, especially Kansas, Nebraska and parts of Missouri. The stalks are sometimes used for fuel, while the seeds are used to feed stock and poultry. A very good oil resembling olive oil is made from the seeds. An acre of sunflowers yields about sixty bushels of seed.

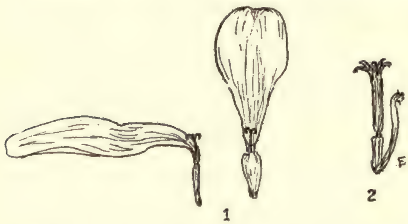


Fig. 6. 1. Ray flowers of a zinnia showing the curled stigmas, the style, ovary, and one petal in the corolla. 2. A disk flower of the zinnia showing the five-lobed corolla attached to the ovary, and the slender bract at one side.

Description. The sunflower is a good specimen to study because its parts are so large. The outside florets with the showy petals are known as ray flowers, while the small inner ones are disk flowers. The disk flowers have all the organs present, the two parted calyx, the five pointed corolla, the stamens enclosed in a tube and the pistil whose style grows up through the midst of the stamen tube with the two curled stigmas at the top. The ovary is at the very lowest part. The small leaflike bodies that you

find attached near the base of the florets are bracts. The same name is given to the over-lapping green bodies that are attached to the underside of the head. This entire group of bracts is called the involucre. It protects the head before it is ready to open up its flowers.

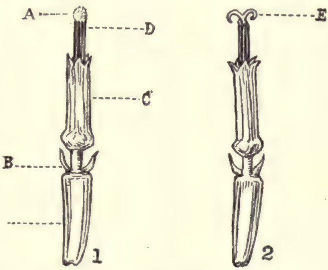


Fig. 7. 1. A disk flower of the sunflower in the early stage of blossoming. 2. The same flower in a later stage. A, Ovary; B, Calyx; C, Corolla; D, Anther tube; E, Stigma.

You probably discovered that the ray flowers do not have either stamens or stigmas; hence they do not produce seeds. They are the showy flowers, however, and probably aid in attracting the insect visitors that transfer pollen from one flower to another.

The regular arrangement of the flowers and later of the seeds in the head is one of the interesting features of the sunflower. The florets open from the outside toward the center, so you can find in the same head all the stages from those that are beginning to wither at the outside to the unopened buds in the center.

Perennials. Look among your perennial flowers for composites. Make a list of all the perennials that blossom in the fall. What parts of these plants live over winter? Why are they called perennials?

Perennials may be used even more than annuals to make your home grounds attractive. By making careful selection you may have perennials flowering from early spring until heavy freezes in the northern states and all the year around in the southern states.

3. Wild Flowers

Study. What wild flowers are in blossom now? Where do you find them? What different colors do you find among them? Are they annuals or perennials? Look at a number to determine whether they have simple or composite flowers.

Make a detailed study of golden-rods. Use the outline suggested for annual flowering plants. Both golden-rods and asters are composites. The heads of the golden-rod are very small and are arranged together at the top of the branches, thus giving the beautiful feathery appearance to the cluster. You will find that they have both disk and ray flowers. Small as the flowers are you can see that both kinds produce seeds.

Watch the changes that take place as the flowers fade. What is the color of the heads when all have gone to seed? What gives them their fluffy, feathery appearance? What adaptation have they for scattering their seeds? Look for different species of golden-

rod. Make a detailed study of asters and other wild flowers. If you cannot go to the fields to watch the changes that take place in these flowers, place a few sprays of each in jars of water indoors. They will continue their development here. Another reason for doing this is that golden-rods and asters are almost as beautiful after the flowers have faded, with their gray, fluffy seed heads, as they are when in full bloom. Even after the seeds with their hairy parachutes have flown away, these plants are still attractive with their dark brown stems and silvery white disks. In order to appreciate the beauty of the landscape during the fall and winter, these should be observed in the fields and along roadsides with other plants.

A few of these wild plants mixed in with your perennial border in the garden will add much to its attractiveness. You can grow them either from seeds or roots.

Discussion. While you are studying flowers both annual and perennial observe carefully the different shades and colors and determine which ones look well growing side by side. You can plan color schemes for flower projects much easier in the fall and summer when you see the flowers themselves, than you can in the spring when you have nothing but seed catalogues to depend upon.

While you grow your flowering plants in order to derive pleasure from their beauty, it is well to remember that, as far as the plants themselves are concerned, their flowers exist not for us but to produce seeds. Scientists tell us, although it has not been proved conclusively, that the bright colors of flowers help to bring insects to them.

It is certain, of course, that the nectar is secreted to attract insects. All this is done so that pollen may be transferred from the anthers to the stigmas. The stamens, which produce the pollen, and the pistils are the essential organs of the flower. When you study botany you will learn in detail about the wonderful process that takes place in the making of a seed. The following paragraphs give only a brief discussion of this process.

The making of a seed. The first step is the transfer of pollen from an anther to a stigma. This is called pollination. The transfer of pollen from an anther to a stigma of the same flower is self-pollination. Cross-pollination is the transfer of pollen from the anther of one flower to the stigma of another flower of the same species.

The pollen is formed in the anther and when it is ripe the anther bursts open and it comes to the outside. The stigma is the part of the pistil that is prepared to receive the pollen. When it is ripe or

ready for the pollen it has a sticky secretion on it, so that if a grain of pollen falls upon it or is brushed from the hairs of an insect it holds this fast. The little grain then germinates and produces a tube-like structure called the pollen-tube. This grows downward through the style to the ovary.

In the pollen-tube two cells are found, called sperm-cells. In the ovary is an egg-cell. When the tube reaches the ovary one of the sperm-cells unites with the egg-cell and forms a new cell. This union is known as fertilization.

The new cell is the beginning of the seed. It grows rapidly for a time, then stops growth, becomes dry, and we say the seed is ripe. When you find a great number of seeds in a pod it means that there was a pollen grain and an egg-cell for every seed that was formed.

Bees, moths and some wasps aid plants by carrying pollen from one flower to another and thus help to insure the production of seed.

CHAPTER II

FARM CROPS

1. Corn

Material. A cornfield in the community; an entire corn plant including the root system. This should be removed from the ground while the leaves are still green. If it is kept in the basement of the schoolroom or other cool place, it will dry slowly and may be used for study any time during the year. Provide also a number of ears of different varieties of corn including several small, unripe ears. These should be removed from the stem when two or three inches in length. They may be preserved indefinitely in a jar of alcohol or four per cent formalin.

Field study. Select a plot ten hills square either in your own plot or in a portion of a large cornfield. What is the distance between the rows? Between the hills? How many stalks in a complete hill? How many hills with one stalk? With two? How many missing hills? What is the actual number of stalks in the plot? What would be the number if each hill had three stalks? What percentage of a perfect

stand does the plot show? How many stalks have one good ear? Two? How many stalks are barren? How many with smut? With suckers? (A sucker is a small stalk branching from the main stem close to the ground. It never bears a good ear, and therefore uses up food with little profit.)

How much greater would your yield be if you had a perfect stand with one good ear on each stalk?

The Corn Plant

Roots. Notice the root system. How many distinct kinds do you find? Describe the main roots

Fig. 8. Root system of a corn plant.

as to number, size and branching. What is their direction of growth? If you have access to a cornfield, dig carefully around a plant to find the rela-

tion of the roots to the soil. How near the surface are they? How deep do they grow? How far out from the hills? How far between the rows?

Where are the brace roots? How many joints on the stem produce these roots? Examine a number of plants and report on the greatest number of joints bearing brace roots. Do they all succeed in reaching the ground? What is the function of these roots?

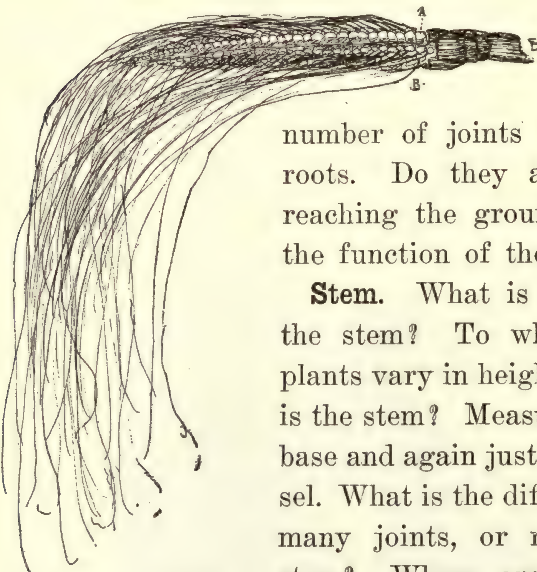


Fig. 9. A shoot showing a row of pistillate flowers. A, Ovary; B, Style.

Stem. What is the height of the stem? To what extent do plants vary in height? How thick is the stem? Measure it near the base and again just below the tassel. What is the difference? How many joints, or nodes, in one stem? Where are they closest together? What is the advantage of this?

With a sharp knife cut a stem into small sections. How many different structures do you find in a cross-section? Describe them. Make a longitudinal section and describe what you find.

Leaves. Count the leaves on one plant. Where

are the longest ones? The shortest? Where and how are they fastened to the stem? What are the parts of one leaf? The lower part that wraps around the stem is called the sheath. The long slender part is the blade. Is the sheath open or closed? What part of the blade is longer, the middle or the margin? What advantage do you see in this wavy margin? Examine the plant where it is hinged to the sheath and describe what you see. What is the chief work of the leaves?

Flowers. What do you find at the top of the stalk? Do you know what the tassels really are? Describe them. Which do they resemble more, heads of wheat or of oats? Carefully remove the husks from a very small ear, one that has just started to grow. Trace the silk down to the cob. What do you find here? See Fig. 9.

Ear. Where is the ear attached to the stalk? How long is the shank or stem? Remove the husks. To what are they attached? Compare the outer with the inner ones. What do you find on the outer ones that leads you to believe that husks are modified leaves? In what condition do you find the silks on a mature ear? How many rows of kernels are there on one ear? Count them on several and get the average. Is the number odd or even? How do kernels at the tip and butt differ from those on the other

parts of the ear? What is the number in one row? If you discard the small kernels at the tip and butt how many will one ear furnish if used for seed? How many hills will it plant if you use three grains in each hill?

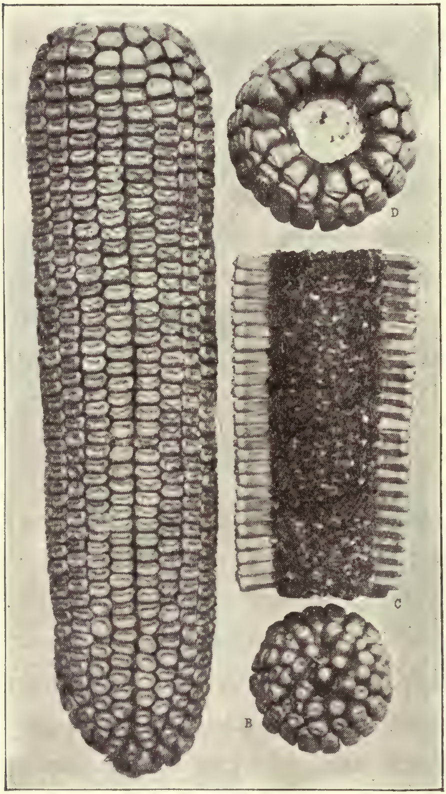


Fig. 10. A, A well shaped and well filled ear; B, A perfect tip; C, Kernels well filled to the tips, wedge shape so that no space is lost; D, A well filled butt.

Selection. In selecting seed, consider the entire plant as well as the ear. Visit a cornfield and select plants from which to choose seed. Look for the following points: 1. An erect, strong, well formed stalk growing in a hill with two others. 2. Well developed brace roots. 3. A plant free from smut and suckers. 4. The ear situated a little above the middle point of the stalk.

In choosing seed corn the chief object that a farmer has is the yielding qualities.

Examine a number of ears and determine what characteristics they have that will make them produce a good yield next year. You will no doubt have the following points:

1. Shape: An ear that is cylindrical will have more kernels than one that tapers too much at the tip.

2. Size: (a) length, (b) circumference. An ear of good length and width will, of course, yield more corn than a smaller ear.

3. Rows: The rows should be close together so there will be no waste space.

4. Tips and butts should be well filled out.

5. Shape of kernels: (a) Wedge-shaped grains have little space between the tips at the cob; (b) a deep grain.

These are the chief characteristics that make an excellent yielding ear. There are two other points, however, that must be given consideration.

6. The ear must be well matured, not soft and flabby.

7. The color of the ear should be true to the special variety of corn. There should be no mixing of colors or grains; white corn should have a white cob, yellow corn a red one.

If you were arranging a sample of ten ears for a corn contest according to these seven points, you should have the ten ears as uniform as possible in shape, size, color, etc.

Value. How valuable is the corn crop in your neighborhood? What is the average yield? The current price per bushel? Look in your geography to determine how corn ranks among grains raised in United States. What states are included in the "Corn Belt"?

Uses. Write a list of all the uses of corn that you know. Make a collection of corn products. Put them into small bottles or vials and mount on stiff cardboard. Make a collection also of as many different species and varieties of corn as possible.

Discussion. No doubt you have discovered in your study of the corn plant that it resembles grass in some of its characteristics. In fact, it belongs to the Grass family. It has fibrous roots which grow in all directions frequently reaching at maturity a depth of from three to four feet. The brace roots help to hold the corn erect.

Stem. The cross-section of the stem showed the outside woody part which gives it strength, and the white pith on the inside with the threadlike fibers scattered through it. These are called fibro-vascular bundles. They are really little systems of canals which carry water and other raw material from the roots to the leaves, and digested food from the leaves back to the stem, roots, seeds, or wherever it may be needed.

Leaves. The chief work of the leaves is to manufacture food for the entire plant. You have already observed that the leaf surface on one plant is very great. This makes possible the manufacture of vast quantities of food so that growth may be very rapid. The wavy margin prevents the long leaves from being

torn in the wind. The projection that you found at the hinge between the blade and the sheathe is called the rain guard. This keeps the water during rains from pouring down between the sheathe and stem. Moisture here would probably result in the growth of mold or mildew.

Flowers. The tassels and small shoots with the silks are the corn flowers. They do not have all the parts of ordinary flowers, but they do have the essential parts. If you have ever seen a corn plant just after the tassels have opened, you have noticed the yellow powder or pollen scattered upon the leaves and even on the ground. If you looked at the tassel closely you saw the stamens that produced the pollen dangling from each of the little side branches, the spikelets. Since the little flowers of the tassel produce only the stamens, they are the staminate flowers. The tiny shoot that becomes the ear has rows of round bodies each with a

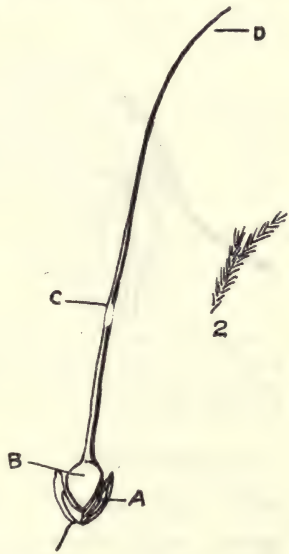


Fig. 11. 1. The pistillate flower of corn. A, The glumes that produce the chaff when the corn is ripe; B, The ovary which produces the kernel; C, The style or silk; D, The stigma. 2. The stigma enlarged to show the hairs that catch the pollen.

silk fastened to it. These are pistils. The round body is the ovary and the silk is the style. This is the pistillate flower because it bears pistils and no stamens. Both kinds of flowers are necessary to produce the seed.

Germination. First pollination takes place; that is, a grain of pollen settles upon the stigma, which is the end of the silk. If the pollen comes from the tassel of the same plant, we say the flower is self-pollinated. If it comes from another plant the flower is cross-pollinated. Most corn in our fields is cross-pollinated. The wind, which is the chief carrier, transfers the pollen from one plant to another.

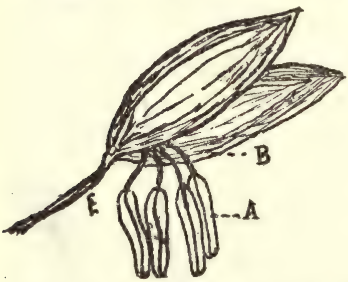


Fig. 12. Staminate flower of corn. A. The stamens as they hang to shed the pollen; B. The leaf-like glumes.

The pollen grain on the silk germinates and forms the pollen tube, which grows downward through the entire silk until it reaches the ovary. In it are two sperm cells, so small that you would have to have a microscope of high power to see them. When the cells reach the ovary, it is ready to receive them. In fact, it has been getting ready for them while the tube has been growing through the silk. In it are two important cells also. One of these is called the

egg-cell, and the other the ĕn′ dō spĕrm cell. One of the sperm-cells from the pollen tube unites with the egg-cell to form a new cell. This has the power to grow until it forms a little plantlet which we call the germ or ĕm′ brý ō part of the corn grain. The union of this sperm-cell with the egg-cell in the ovary is called fertilization. This must always occur before the germ or embryo can be formed.

The second pollen tube cell unites with the endosperm cell of the ovary and the resulting new cell grows into the large starchy part of the corn kernel, which is called the endosperm. This is simply a storehouse of food placed around the little germ to supply it with nourishment while it is developing its first roots and leaves. It is because of the fact that plants in this and similar ways store so much nourishment in their seeds to furnish food for the little embryo that seeds are so valuable as food for men and animals.

As the seed germinates and grows the endosperm is used up. By the end of the season it has disappeared; but the embryo grows into a new plant. Just what kind of plant it will be and what kind of corn it will produce depend largely upon the character of the plants that produced the pollen grain and the ovary cell that united to form the beginning of the seed. You can easily see from this why the charac-

teristics of both plants are so important and why corn growers should select for seed ears as nearly perfect as possible, grown upon plants of the kind they wish to produce. If it is desired, a detailed study of the grain may be made at this time instead of in the spring. See Fig. 30.

Selecting and storing seed. The best time to select seed corn is early in the fall before heavy frosts, and the best place is in the field, not in the crib. You

Fig. 13. Seed corn rack.

have already discovered the important characteristics to consider in choosing corn for seed. After the seed is selected comes the question of storing it for the winter. Certain conditions are essential for keeping the seed corn:

1. The atmosphere should be dry.

2. The temperature should be even and not too cold.

3. The ventilation should be good.

A simple method is to tie a number of ears together and hang them up in some convenient place such as an attic, dry shed, or an unused room. Agricultural colleges have suggested a number of methods. See Fig. 13.

Uses of corn. Corn is used most extensively as food for stock. Not only is the grain used, but also the stem and leaves as green or dry fodder, the whole plant in silage, the bran in ground feed, and the germs in corn-oil cake.

Corn also furnishes a large supply of human food in the form of corn-meal, breakfast foods, hominy, corn starch, syrup and oils.

Corn oil is manufactured into rubber from which boots, shoes, tires, linoleums and oilcloth are made. It is used also in the manufacture of soap and in the mixing of paints. The cellulose from the stem is used to a slight degree in the manufacture of paper. The cobs are used in the manufacture of pipes and also for fuel. Even the stalks are used for fuel in some of the western states.

History. Corn is a native of the New World. The Indians called it maize. Its original home was prob-

ably in Mexico or South America. When America was settled by the colonists, corn had already been domesticated by the Indians, who taught the white man how to grow it.

Types. There are six important species of maize.* The most valuable variety is Dent, which is our common field corn. It gets its name from the dent in the

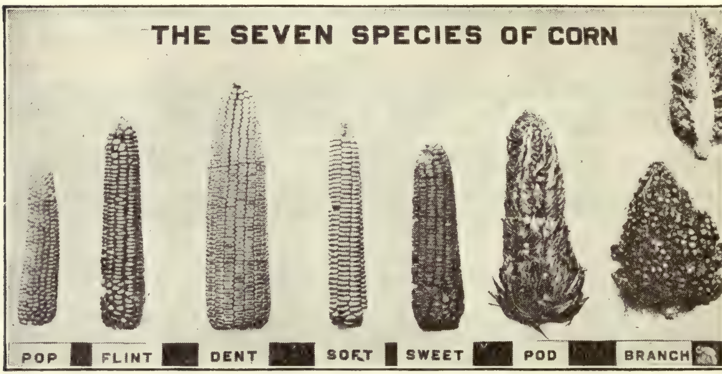


Fig. 14. Seven species of corn.

crown of the grain. There are many varieties of Dent corn including all the white and yellow as well as the red and mixed colors.

Flint corn has a smaller ear than Dent, with from eight to twelve rows of kernels. The grains are smooth and hard. This corn is used largely as fodder and silage. It is the chief corn grown in the northern tier of states.

*A new type, the branch corn, has been developed, but as yet has no commercial significance.

Sweet corns are known by their wrinkled grains and their large percentage of sugar. As green corn they are used largely for human food. It is said that the first sweet corn cultivated in America was secured from the Susquehanna Indians in 1779.

Pop corn is characterized by its small grains and its power to turn wrong side out when heated. When corn pops, the moisture in the grain vaporizes and expands. It is held in by the hard covering which at last explodes.

Pod corn is rarely seen. It is raised chiefly as a curiosity. Each grain is enclosed in a little husk or pod of its own. The entire ear is also inclosed in husks. This is of interest because it is supposed to be the original type of corn from which all the others have sprung.

Soft varieties of corn are raised only in southern regions. The mummy corn of Chile and Peru is said to belong to this group.

2. WHEAT*

Material. Specimens of entire wheat plants, samples of grains, collection of wheat products, plates or boxes for germination tests.

*Note. Wheat and other farm crops that provide food or clothing may be studied with profit either in the city or country. While the lessons are suggested for the fall, they may be used equally well in the spring in regions where spring wheat is grown. Since in

Study. Make a list of the different foods that are made from wheat. Look at labels on boxes of cereals or breakfast foods, macaroni, etc. What different kinds of wheat flour do you know? How do breads made from these differ? Begin at once to make a collection of wheat products. Place them in small vials, label and fasten by means of fine wire to a sheet of stiff cardboard. A chart showing heads and grains of different varieties of wheat will also be of interest.

The wheat plant. Examine a wheat plant. Describe the roots. How tall is the stem? Break it and describe the inside. How are the leaves fastened to the stem? How many distinct parts to each leaf?

The head. We call this kind of flowering head a spike. Each of the branches is a spikelet. How many spikelets in a spike? Count the number in each head and get the average. How many divisions in one spikelet? How many grains? If you have more than one variety of wheat compare them as to the number of spikelets and grains. Estimate the whole number of grains in one head. Carefully pull to pieces what is left of the flower inclosing the grain. Each small

many places the study of the plant must be made at a time when field study is impossible, every school should have as a part of its equipment a number of specimens of entire wheat plants. They may be kept from year to year by tying them into small bundles and hanging them up. It will add to the profit of the study if several varieties are used. There should be at least one specimen of bearded and one of beardless wheat.

leaflike body is a glume. If the wheat is a bearded variety, note to what the beard or awn is attached.

The grain. Examine a grain and write down everything that you see. Determine which end of the grain was fastened to the stem. How deep is the crease in the grain? Compare dry grains with those that have been soaked over night, noting differences. Split open a dry grain. What do you find on the inside? Open a soaked grain and compare with the dry one. What part of the grain is used in making pure wheat flour? Whole wheat flour? Bran? What part produces the new plant?

Purity test. Spread a small handful of wheat on a piece of white paper. Now separate the weed seeds and other foreign objects from the grain. Put the wheat in one pile and the foreign matter in another. Estimate about what proportion is pure seed. If you have a pair of balances, weigh each and get exact per cent of purity. If you find weed seeds, determine if possible what kind they are. This is a good time to refer to your weed list, which you will find on page 77.

Germination test. If you are planning to sow wheat, you should make a germination test. To do this, take one hundred grains from a sample of seed wheat. Place moist sand or soil in a dinner plate or shallow box. Scatter the seeds on the surface of

the sand not allowing any two to touch each other. With your finger gently press each grain so that it will rest firmly in the sand, but do not cover it. Turn another plate over this one to keep the moisture in. Set it away in a warm place.

Watch for the germination of the seeds. How long after the planting before the first small sprouts appear? Watch them from day to day until you are certain that no more grains will sprout. By counting the grains that have sprouted, you will be able to determine at once the per cent of germination. If you sowed only the usual quantity per acre, what percentage of a perfect stand would you expect to get from the tested seed?

Study. Examine one of the sprouted grains. From what part do the roots grow? How many roots are there? Where does the shoot appear? Which grows more rapidly at first, the roots or the shoot?

Plant some wheat in a box, keep it moist and watch the growth of the plants. If you have a school garden or a small plot on the school grounds that may be used, plant some out-of-doors and watch it at intervals all fall and winter. What change takes place in the habit of growth when it is about six weeks old? What advantage is it to the plant to spread out rather than to grow erect? To what extent do the plants remain green over winter? Explain why

a vast amount of snow is a benefit to the wheat crop.

What enemies has wheat? How may they be combated? The Hessian fly and the chinch bug are among the worst insect foes. Rust and smut are common fungous diseases.

Discussion. From your observation you find three distinct parts to each grain of wheat; the covering, or hull from which bran is made, the starch which constitutes most of the white flour, and the small dark body, the embryo. The embryo is the little plant that develops its root and shoot when the seed is kept sufficiently warm and moist. The starch furnishes food for the growing plant. In whole-wheat flour the embryo and the inner covering of the grain are used as well as the starch. Graham flour is a mixture of finely ground bran and ordinary flour.

Varieties of wheat. Wheats are divided into spring and winter varieties. Winter wheats are planted in the fall and live through the winter beginning their growth again in the spring. Spring wheat, as the name indicates, is planted in the early spring and matures its grain the first season.

There are hard and soft varieties of both spring and winter wheat. Winter wheats are preferred in all regions where the extremes of temperature are not too severe for them, because they yield more than spring wheats. They are ready to harvest ear-

lier, and are better able to withstand attacks of insects and fungous diseases. Almost two-thirds of all the wheat grown in the United States is winter wheat.

Kansas and Nebraska are the centers for the hard winter wheat; the middle western states raise semi-hard wheat; while the southern states raise both semi-hard and soft. The great wheat regions of the North, Minnesota and the Dakotas, raise hard spring wheat.

There are a great many different varieties of all these kinds of wheat. You may be interested to know how new varieties are obtained. There are two ways. Perhaps some of you have noticed in walking through a wheat field that here and there a few heads seem somewhat different from the rest. Wheat is likely to have "sports," or variations. That is why these plants differ from others though grown from apparently the same kind of seed. Breeders who wish to obtain new varieties select one of these heads that seems to have good characteristics. They save the seeds and plant them in a small plot by themselves. If during the first year the good characteristics seem to persist, the seed from this small plot is preserved and planted on a larger plot. In a few years there is enough seed to plant a number of acres. If the variety proves valuable, the breeder

gives it a special name, and a new variety of wheat is soon on the market. This is called the "selection method."

A second method is by means of "cross pollination." Wheat does not cross pollinate naturally as corn does. This is because the flower is so arranged that the pollen does not escape but falls upon the pistil of the same flower. If breeders wish to cross pollinate wheat, they must do it by hand. This is a kind of work that requires special training and must be done by experts. The stamens of one flower are carefully removed and on the pistil of this flower pollen from the flower of a different variety is placed. In this way characteristics of the two plants are mingled in the new seeds that are formed, and a new variety may be produced.

Planting wheat. What methods of planting or sowing wheat are employed in your district? If possible visit a farm and examine a drill and a broadcast seeder. The drill plants the wheat in rows about eight inches apart. The seeder scatters it broadcast over the field. In the early days farmers sowed wheat broadcast by hand.

Value of the wheat crop. How many farmers in your district raise wheat? What is the average yield per acre? What is the price per bushel? How important is the wheat crop in United States? About

one-fifth of all the wheat raised in the world is produced in United States. This amounts annually to something over 700,000,000 bushels. With the help of your geography locate the wheat regions of our country to find out what large cities owe their prosperity to the manufacture of wheat into flour and other products. Besides the grain the straw is of value as food for cattle and horses. The yield of wheat varies greatly in different localities. Some fields yield as low as fifteen bushels per acre. Others yield fifty and sixty.

Wheat project. If you live in a region where wheat is an important crop, you may be interested in starting a plot of your own. Follow the directions for planting oats, page 183.

3. Grasses and Legumes

Material. Grasses and clovers found in the community, specimens showing roots, collections of leaves, flowers, and seed heads, for study and booklets.

Study. Name all the different places in your neighborhood where grasses of some kind are growing. To what extent do you find roadsides, vacant lots and railroad right-of-ways covered with grasses?

Meadow grasses. What grasses do you find in meadows? Does one grass constitute the entire

meadow or is there a mixture of plants? Examine a timothy plant. What is its habit of growth? Does it grow in clumps or spread evenly over the ground? Dig down to the roots. Describe them. How deep do they go? Describe the leaves; the flowering head. Which does it resemble more, a head of wheat or one of oats? What is timothy used for? When is it harvested? How is it kept for future use? What other meadow grasses are grown in the community? Compare them with timothy noting resemblances and differences. If timothy is not grown in the region where you live, choose your chief meadow grass and study it using the topics suggested for timothy.

Pasture grass. What is the chief pasture grass in your district? Study the habits of growth, especially the underground parts. See outline for blue-grass, page 452. What characteristics make a good pasture grass? Are timothy and blue-grass perennials or annuals? What annual grasses are grown in your neighborhood? For what purposes are they used?

What is the value of timothy hay per ton? What is the average yield in tons per acre?

Clovers. How many kinds of clover grow in your district? Examine a red clover plant. How many stems do you find in the loose rosette? Where do you find the youngest shoots? What is the advan-

tage to the plant of growing close to the ground? Describe the leaves. Look at the leaflets after sunset; what change in position do they take? Study the flowers. Decide whether the clover head is a single flower or a cluster. How many flowers in one head? Which open first, those at the lower or upper portion of the head? Look closely at one small flower. What common garden flower does it resemble? Where is the nectar secreted? What insects are commonly found feeding upon it? Find a withered head and look for the seeds. How many seeds does each small flower produce? What shape are the seeds?

Dig up a clover plant. If the soil is very hard and dry, water it thoroughly the preceding day. Describe the root. What is the advantage of its great length and thickness? Which remains green longer during a summer drought, clover or grasses? Why? Look carefully on the roots for small roundish bodies about the size of pin heads. These are called tubercles or nodules. On what part of the root are they most numerous? Count the nodules on one small root. What are these nodules and why are they on the roots?

How many crops of clover are harvested in one season? Which crop usually produces seed? What is the price of the seed? How valuable is clover

hay? For what other purpose than to feed stock is clover grown? When and how is it planted?

Find other clovers and compare with red clover as to habit of growth and uses. How does white clover spread? Why is it a better pasture than meadow grass? What characteristics have all clovers in common?

Fig. 15. Harvesting alfalfa.

Sweet clover. Make a study of sweet clover using the above topics. Which does it resemble more, red clover or alfalfa? How many of the farmers in your district raise sweet clover? What is the length of life of a sweet clover plant?

Alfalfa. Describe an alfalfa plant. How many main stems has it? Does it grow more or less erect than red clover? Compare the leaves with those of clover noting resemblances and differences. How do the flowers differ from those of clover? In what

are they similar? What kind of a root has it? Look for nodules. To what extent is alfalfa raised in your community? How many crops does it produce in one season? How does it compare with clover as a forage crop?

Soy-beans and cow-peas. If these plants are grown in your district, study them noting how they grow and what kind of leaves, fruit and seeds they have. Determine whether or not the roots have nodules. What use is made of these plants?

Discussion. Grasses and legumes are important forage crops providing a large per cent of the food of domestic animals. They are classified with reference to methods of feeding into meadow, pasture, and soiling crops. In pastures animals help themselves to the growing plants. Meadows are cut, the plants air dried or cured, and stored as hay for future use. Soiling crops are cut green and immediately fed to the animals.

Blue-grass is the most important pasture grass in the northern states. Frequently white clover is mixed with it. In the southern states Bermuda is the chief pasture grass. The characteristics that make these desirable pasture plants are: 1. They form a thick sod that stands trampling and crowds out weeds. 2. They have fine blades that stock like to eat. 3. They are hardy and able to endure extremes of

cold or drought. The first and third characteristics are due to their method of spreading by the underground stem or rootstock.

Timothy is the chief meadow grass. Redtop, meadow fescue and orchard grass are used in some regions where timothy does not thrive well. In many localities a mixture of red or alsike clover with timothy is used. Sudan grass, a very tall productive variety, is coming into use in a number of states.

All of the grasses we have discussed are perennials. Some farmers raise millets, which are annual grasses, and use them for hay or pasture. Perennial plants are those which grow year after year. Annuals grow for just one year.

You found that all the grasses have certain characteristics in common: 1. Long, narrow, parallel-veined leaves. 2. Numerous small fibrous roots. 3. Jointed stems. You found two kinds of flowering heads represented by timothy and blue-grass. The timothy head is a spike; blue-grass, a panicle. All of our small grains, as well as corn, sorghum and kaffir corn, belong to the Grass family.

Legumes. The clovers, alfalfa, cow-peas and soybeans belong to the *Legumenosae* family, but they are commonly called legumes. They get the name from the flat pod in which the seeds are borne, which is characteristic of most of the family. Such a pod is

called a legume. Our garden beans and peas are good types of legumes. You probably discovered the similarity between the flowers of clovers and those of peas and beans.

Legumes are excellent forage plants containing more nutritious foods than grasses. This is especially true of alfalfa and red clover. Alfalfa is raised more in the western states; clover in the states east of the Missouri river. However, the acreage of alfalfa is increasing year by year. Sweet clover is beginning to find a place as a forage crop. Many farmers in the Middle West are growing it instead of alfalfa.

Red clover produces two crops each year. The first is harvested for hay; the second usually for seed. In the West alfalfa is cut from six to ten times in one season. In the Mississippi Valley and adjacent states it is possible most seasons to secure three cuttings. Sweet clover also yields three cuttings. It must be harvested when young before the stems become woody.

Soy-beans and cow-peas are frequently used as soiling crops, but in the South they are harvested for hay. They are annuals. Alfalfa and red and white clover are perennials; sweet clover is a biennial.

In addition to their value as food for animals, legumes are important plants to aid in maintaining soil fertility. They do this in three ways:

1. They furnish a large amount of decaying roots, stems, and leaves that enrich the soil.

2. Their long thick roots which penetrate the soil so deeply aid in making it porous and in giving both air and water a better opportunity to reach the roots.

3. They supply the soil with nitrogen, an element that all seed plants must have in order to live and grow.

You found nodules on the roots of clovers and other legumes. These are growths caused by small living organisms called bacteria. (One is a bacterium.) The bacteria, which are either on the seed or in the soil, attach themselves to the young clover roots. The tissues of the roots grow around them forming the small nodules. In these the bacteria live and multiply very rapidly. They take free nitrogen from the air in the soil spaces and change it into a form that clover can use, for, although there is plenty of free nitrogen in the air surrounding clover and other plants, they cannot use it in that form.

All the legumes have the bacteria nodules on their roots. They are not only supplied with all the nitrogen they need, but their leaves, stems and roots are all well stocked with it. If the plants are plowed under, the nitrogen, which is now in the form of a compound called a nitrate, goes into the soil and furnishes a supply for other crops that are grown here.

Nitrogen is frequently lacking in soils that are constantly used for crops, so you can realize how important it is to grow legumes in order to keep a sufficient supply of nitrogen in the soil.

4. Cotton

Material. An entire cotton plant, some ripe bolls, pictures of cotton gins and cotton factories, collection of cotton products.

The cotton plant. Study a cotton plant either in the field where it is growing or have one in the school room. How high does the plant grow? Examine the root and describe it. How deep in the ground does it extend? Describe the stem. How close to the ground does it begin to branch? Count the number of large branches. Break or cut a stem at the largest part. What parts can you find in the cross-section? How does the structure differ from that of the corn stem?

Describe a leaf. Compare leaves found on different parts of the plant. What is the greatest number of lobes that you find in one leaf? The fewest? What is the most common number? Which have the greatest number, those on the upper or lower branches? How are the leaves arranged with reference to each other, opposite or alternate? Look on the under side of a leaf for a little hollow spot

near the base of the midrib. What is in this depression or pit? How many such pits can you find on one leaf? Taste the liquid.

The flower. Examine a flower. What do you find at the lower part? How many fringed bracts are there? Describe them. Pull them back till you can see the cuplike calyx with five or six notches at the top. What color is it? How many petals are there? What different colors do you find? Look at flowers of different ages to see if you can account for the different colors. What insects have you seen around the flowers? What do you find in the center of the flower? You find a great number of stamens all grown together to form a large tube. Remove the stamen tube. In an old flower it will come off easily leaving the pistil which is in the center of the flower. Find the large green ovary at the base of the pistil. Note the slender style and the stigma at the top. How many division lines has the ovary? Find flowers that are withering, and those from which the withered parts have dropped. Determine what part of the flower develops into the fruit or boll. What other parts of the flower remain attached to the boll?

The seeds. Cut open lengthwise an ovary from which the dried corolla and stamens have just fallen. Note position of the rudimentary seeds. Cut open another that is about an inch long and note the white

silvery substance growing around the seeds. Cut open one that is still larger to find that the white substance is forming into threadlike fibers. Study a ripe boll. Where does it open? How many sections has it? Remove the fibers from the seeds. Where are they attached? How many seeds in one section? In one boll? Count a number to find variations. Straighten out the fibers on one seed. How long are they? Twist some of them together and note their strength.

Remove the cotton films from around the seeds and examine the seeds. Take off the hull and study the kernel. Crush some of the kernels on a piece of paper. What do you find?

Discussion. From an economic standpoint cotton is one of the most important crops that we have in the United States. You found that the plant grows from three to six feet in height. It has a large taproot that sends out a number of branches. These grow to quite a depth and anchor the plant firmly in the soil. The stem resembles that of a shrub or tree with a brownish bark. Inside the bark is a strong layer of wood and in the middle is the pith. The stem is unusually strong and woody for an annual. In fact, in warm climates it is a perennial living on from year to year just as our shrubs do.

The leaves are arranged alternately and the upper

leaves have more lobes than the lower ones. One of the most interesting things about the leaves is that they secrete nectar. On the under side of the midrib not far from the base is an oval shaped depression or pit. In this the sweet nectar collects. Sometimes a large drop stands up like a bit of honey. On some leaves a number of the veins have these pits, while on others you may not find any.

The flower has at the lower part three fringed bracts that enclose the bud and later the fruit. When the flower first opens the petals are a creamy white. A little later they become a pale pink. The next day they have changed to a reddish purple. They then begin to wither slightly and usually fall by the close of the second day. The plant begins to blossom early in the summer and continues blossoming all summer and early fall, so you may find on the plant at the same time flowers and fruit in all stages of development.

The ovary develops into the fruit or boll. The fringed bracts still remain on the bolls. Cotton growers call these the "squares." There are usually five sections in the boll, which split open at the top. The fibers are fastened to the blunt upper end of each seed. They are long, strong fibers. These characteristics make them very valuable for spinning and weaving. After the fibers are removed the seed

remains covered with a soft coat called linters. The outside covering of the seed is rather hard. The kernel is white and contains considerable oil.

History. Cotton has been in use since the beginning of written history, and no one knows how long before. Its earliest known home is India. From here it was introduced into Egypt and other warm countries of the eastern continent.

Columbus found cotton in the New World in the West Indies. It was also found in Mexico and South America by some of the early explorers.

Cotton was introduced into the southern states early in the history of the colonies. Two distinct species are raised here, the sea-island and the upland cotton. The former is raised along the coast of South Carolina, Georgia, Florida and in the West Indies. The upland cotton is grown in most of the other cotton growing states. Cotton may be raised with profit as far north as 30°. Look on a map to find what states are included in the cotton region.

Uses. The fibers are removed from the seeds by a machine called a cotton gin. The seeds rest against the teeth of a number of revolving saws which pull the fibers from the seeds. You know from your study of history how very important the invention of the cotton gin was. After the cotton is ginned it is pressed into large bales and shipped to the cotton

factories where the fibers are spun into threads and woven into cloth.

The seeds are taken to another machine which removes the linters. This product is used in the making of mattresses, in upholstering furniture and in making cotton felt cloth.

The hulls are removed from the seeds, crushed and used for fertilizers or are fed to cattle. The kernels are pressed in a great pressing machine in order to obtain the oil that is in them. The oil is used for cooking purposes and to serve with salads instead of olive oil. It is used in the industries especially in mixing paint and making soap.

The pressed remains of the kernels is known as oil-cake. It is used to feed cattle and is usually sold in the form of cotton-seed meal.

In some places where fuel is scarce the larger parts of the cotton stems are used for heating purposes.

Culture. Cotton is planted in rows from three to four feet apart. It is cultivated in much the same way that corn is. Weeds should be kept down and a soil mulch produced to conserve the moisture. Cotton growers are giving much attention recently to the selection of good seeds. Plants that produce bolls early and produce them in large numbers are marked and the seeds from these plants saved for the next crop. By this simple selection method the crop in

some regions has been increased from 15 to 25 per cent in a period of three years.

Cotton projects. If you live in a region where cotton is raised, you should plant a small plot of your own. Try saving the seeds from the plants that produce well and see to what extent you can increase your yield.

Make a collection of all the different products derived from cotton. Mount these on a chart.

Make a list of all the uses of cotton that you know. How valuable is the cotton crop in your community? In the United States?

CHAPTER III

WEEDS

Material. A collection of weed-plants, leaves, fruit, and seeds. Stiff paper for charts or booklets.

Study. For study you may group weeds with reference to the location in which you find them growing; as garden, lawn, pasture and meadow, roadside, vacant lot and field.

Go into your garden, yard or field and count the number of different kinds of weeds that are growing there. Write the names of those that you know. How close together do the plants stand? To what extent are different species growing together?

Make a special study of each kind. Use the following outline to keep a record of your work:

1. Name:
2. Location: garden, lawn, pasture, roadside, cultivated field, meadow, etc.
3. Annual, biennial, perennial.
4. Habit of growth: erect, procumbent, creeping, climbing, etc.
5. Characteristics of underground parts: a. roots, thick, fleshy, long, fibrous. b. underground stem, rootstock, long branching, etc.
6. Leaves: simple, compound, smooth, hairy, large, small.
7. Flowers: kind, simple or composite; dates of flowering, special characteristics.

8. Fruit: date of maturing; seeds, large, small, number, special adaptations for distribution.
9. Methods of control.
10. Native home and interesting facts.

Pigweed, sometimes called careless weed, abundant in many gardens and fields, is a good one with which to begin. It is an annual; that is, it starts from the seed each year, produces seed and then dies. It has a thick taproot with many branches. The leaves are simple, large on the lower branches and small on the upper ones. The flowers are very inconspicuous, growing in dense, greenish clusters.

The seeds are small and are produced in great numbers. You can easily estimate the number of seeds on one plant by counting the exact number on a small branch, then count the number of branches of the same size and calculate the entire number of seeds. The easiest way to get the seeds is to rub them out of the chaff onto a sheet of paper. If you have patience you can remove all the seeds from a large plant and put them into a jar or bottle. This gives a very accurate idea of the great number of seeds that one plant produces, and explains why the weed is so abundant.

Compare with pigweed other annuals as smartweed, foxtail grass, and rag weed, noting characteristics that are common, and those that are dissimilar. Find some plants whose stems were cut off a few

inches above the ground earlier in the season, and describe what has taken place.

Find in vacant lots, pastures or roadsides, some types of biennial weeds; that is, weeds that grow from seed the first year, blossom the second year, bear fruit and die.

Some of the most familiar biennials are burdock, field or bull thistles, wild parsnip and wild carrot. Find plants of the first year's growth and those of the second. Compare them noting differences.

In lawns, pastures and in some cultivated fields you will find weeds whose underground parts continue to live year after year. Each year they send up new stems and leaves, blossom and bear seeds. These are perennials. Dandelion, plantain, curly dock, creeping mallow or cheese weed are common perennials. Make careful observation of their underground parts to determine how they live through the winter. Note also any special adaptations they may have to spread by means of roots or underground stems. Summarize the great number of characteristics that such a perennial as the dandelion has that make it a successful lawn plant.

Compare weeds of the same species growing in different locations, as a dandelion on the lawn with one growing in tall grass. How do you account for the difference?

Begin at once making a collection of the weeds of your neighborhood. Press a leaf of each species and when possible a flower. Preserve also fruiting heads or pods and seeds. Mount your specimens on cardboard making a weed chart or booklet.

The easiest way to press the plants is to spread them out on a piece of newspaper, taking care to smooth out the leaves, then place several layers of the paper on top. Lay them down flat and put a weight upon them. After an interval of several days all moisture will have been absorbed and the plants will be ready for mounting. There are two ways to mount them. You may use small strips of paper, with mucilage on one side, to form loops over the stems; or you may sew the specimen fast to the sheet.

Discussion. Most garden weeds and those found in cultivated fields are annuals. You found that pigweed, foxtail, smartweed and crab-grass each produces a large number of seeds. This is characteristic of most annuals and is of great importance since these plants are wholly dependent upon seeds for reproduction.

An interesting fact about the seeds is that they do not all germinate and grow at the same time. No doubt you have weeded your garden during the growing season and then have gone back within a week to find another crop of weeds of the same kind.

If you continue this all summer, the weeds will still continue to grow to a certain extent. The seeds of some weeds probably remain a number of years in the soil before they finally germinate and grow. Agriculturists have found by experiment that only one of the two seeds of the cocklebur grows the first season. The other one may grow the second year or may wait several years.

Another characteristic that is an advantage to annuals is that they may start to grow in the middle of the summer after cultivation has ceased and yet succeed in maturing their seeds before cold weather. Some of them, like the pigweed, cocklebur, foxtail and others, when cut off, send out new branches from the injured stems, blossom and bear seeds in spite of the injury.

The dandelion has many characteristics that make it a successful plant. It is so hardy that it can blossom and produce seeds when the temperature is quite low. In some places where it is sheltered even in the North Central States it produces seeds all winter. Its large root provides food for rapid growth in the spring. You probably found in the heart of the rosette tiny buds that are ready to open up just as soon as conditions are favorable. The growing center of the rosette is below the surface of the soil so that a lawn mower does not injure it in the least.

In fact, the mower is a friend of the dandelion, since it cuts away the grass allowing plenty of light to reach the weed. The milky secretion, which is bitter, is not liked by most animals, so the plant is not cropped when it grows in pastures. In addition to all these characteristics for successful growth, it has a great number of seeds that may be carried long distances by the wind.

The dandelion leaves are used for greens and salads and the root for medicine, so, while we often regard it as an undesirable weed in the lawn, it also has useful qualities. In some places near large cities it is grown in gardens to supply the market with greens.

The thistle, burdock, and other biennials grow from seeds and produce large fleshy roots and a number of leaves the first year. The second year they send up a flowering stem and use the great supply of food they have stored in the roots to produce seeds.

Annuals are usually found in gardens and cultivated fields. Since they start from seeds each year the open plowed ground gives them a chance to get a foothold. They have little opportunity to start in lawns, meadows and pastures because the space is already occupied, and there is no good place for the seeds to settle down and germinate.

Perennials are most abundant in pastures, old meadows and roadsides; but even perennials have a hard

time to gain a foothold in grassy areas. Some of them get fairly well started but are crowded out by the grasses. The only perennials that succeed in holding their places are those that have special adaptations like the dandelion, the Canada thistle, milkweed, curlydock and different kinds of daisies. Perennials when once established are the hardest of all weeds to combat, because they not only produce seeds for new plants but the old plants continue to live. Many of them also spread by their underground stems.

There are a few perennials that thrive well in cultivated soils. Among them are the wild morning-glories, one with a large white flower, the other with a pink flower sometimes called wild sweet potato. Quack grass is perhaps even worse than the wild morning-glories. All of these spread by underground stems called rootstocks. A small piece of stem under right conditions starts a new plant, so that cultivation often tends to scatter these weeds instead of destroying them.

Many weeds of all three classes possess special devices for distributing their seeds that aid them in getting possession of new fields. You have observed the feathery pappus fliers of the thistles, wild lettuce, and dandelion, the burs of cocklebur and burdock, the tumble weeds that roll along scat-

tering their seeds as they go, as Russian thistle, and old witch grass. Some smooth seeds of such plants as the ragweed, velvetweed, and pigweed are carried long distances, and are blown over the snow and ice in the winter time. Water helps to distribute seeds by washing them down slopes, by carrying them in streams and scattering them over the land during the high waters in the spring.

Why weeds are not desirable. Make a list of all the reasons you can think of why you do not wish weeds to grow in your fields and garden.

1. They use up moisture and mineral foods that you would like to have left for your cultivated crops.
2. As a rule, they are rapid growers and can easily shade the smaller cultivated plants.
3. Many of them can thrive in crowded conditions better than some of our cultivated crops.
4. In grain fields they increase the cost of harvesting by occupying a large space in the sheaves.
5. In threshing, some of the seeds are certain to become mixed with the grain, thus making it inferior either for market or seeding purposes. The same thing may be said of weeds in meadows. Hay with a large per cent of weeds is not as valuable as pure hay.
6. Some weeds are detrimental because they are poisonous to stock.

7. Some provide a shelter for injurious insects during the winter.

8. Many weeds are such coarse, unsightly plants that we do not like to see them around a home or farm.

Getting rid of weeds. How to get rid of weeds is a problem that all gardeners and farmers must face. The more you know about the lives and habits of these plants, the better able you will be to exterminate them. Annuals have but one way to reproduce themselves; if you can prevent their producing seeds, it will not take many years to eradicate them altogether. Rotation of crops aids greatly in controlling these weeds.

Biennials may be controlled in much the same way as annuals. If they are dug out the first year or cut down and burned the second year before the seeds mature, they are easily destroyed. It does little good to cut off their tops before they send up their flowering stems, for they will continue to grow and send up new stems until they have a chance to produce flowers and seeds.

Perennials are harder to handle since they are not dependent upon seeds for reproduction, but continue to live and spread year after year. Sometimes a change of crop will help to eradicate them. Pastures and meadows that are badly infested with

perennials and biennials should be plowed up and planted to grains. Perennials in small plots may be dug up root and all and burned. A method sometimes used is to cover a small plot with a thick coating of straw or manure. Sometimes tar paper is used instead. This covering prevents the leaves from manufacturing food since they are entirely shut off from the sunlight. The roots cannot live long without food so the plants are really starved to death. This method is too expensive to use except in small tracts. Another method that is successful although very expensive is known as fallowing. Instead of trying to raise a crop of any kind the farmer plows under the first crop of weeds in the spring, then discs the soil every few days during the growing season so that no leaves have an opportunity to get above the ground and manufacture food.

You will be interested to know that most of our worst weeds are not natives of America. They have been introduced from other countries, usually with the seeds of cultivated crops. Some were brought over by the early colonists. Others have come in rather recently. Most of them possess characteristics that enable them not only to gain a foothold in our soil but to keep possession even in the face of hard conditions.

LIST OF COMMON WEEDS

Explanation of Terms and Symbols

The letters (A), (B), (P), following the name indicate whether the weed is an annual, a biennial, or perennial.

The scientific name is found in parentheses after the common name of each weed.

Fam. stands for the name of the botanical family to which the plant belongs.

Hab. stands for habitat and tells the place in which the weed is found growing most abundantly.

N. H. gives the native home of the weed or the country from which it has been introduced.

Char. Under this term the characteristics that make the weed hard to combat are given.

Control. Some of the best methods of combatting each weed are suggested.

Butter print, velvet leaf: (A); (Abutilon, abutilon); Family, Mallow; Hab., Cultivated fields, gardens; N. H., Asia; Char., Many seeds scattered by the wind shaking the tall stem. Leaves covered with soft hairs which enable the plant to stand drought. Control, Pulling or hoeing before plants blossom. Cutting mature plants, piling and burning.

Burdock: (B); (Actium, minus); Fam., Thistle; Hab., Vacant lots, waste places, fence corners; N. H., Europe; Char., Deep thick roots, lower leaves very large. Fruit a bur. Seeds scattered by animals; Control, Deep cutting below crown before flowers appear. Cutting, piling, and burning mature plants.

Buckhorn: (P); (Plantago lanceolata); Fam., Plantain; Hab., Fields, meadows, pastures; N. H., Europe and Asia; Char., Thick rootstock which lives over winter. Flowers and bears seeds from April to October. Seeds scattered in clover, alfalfa, and other hays; Control, Plowing under meadows or pastures and cultivating thoroughly. Where plants are few, cutting out.

Wild carrot, Queen Anne's lace: (B); (Daucus carota); Fam., Parsley; Hab., Roadsides, lawns and meadows; N. H., Europe and Asia; Char., Long root, numerous seeds distributed by wind, birds and water; Control, Cutting roots well below crown. Repeated cutting during summer.

Canada thistle: (P); (Carduus Arvensis); Fam., Thistle; Hab., Pastures, waste places; N. H., Europe; Char., Spreads by a running rootstock from 2 to 3 ft. deep. Seeds scattered by wind. Control, Covering with tar paper or other material for an entire season or two to starve out the rootstocks. Repeated cutting during the growing season for at least two years.

Chickweed: (A); (Alsine media); Fam., Pink; Hab., Moist places, edges of gardens, meadows, lawns; N. H., Europe and Asia; Char., Blossoms all spring and summer. Many seeds; Control, Rotation of crops. Crowding out by winter crops as rye, or crimson clover.

Cocklebur: (A); (Xanthium glabratum); Fam., Ragweed; Hab., Cultivated fields, especially in moist ground, in cornfields; N. H., Europe; Char., Hardy, rapid grower. Sends out new branches when stem is cut off. Bur widely scattered by animals; Control, Pulling before burs are formed. Burning mature plants.

Corn-cockle: (A); (Agrostemma Githago); Fam., Pink; Hab., Grain fields, especially wheat and rye; N. H., Europe and Asia; Char., Many small seeds. Blossoms all summer; Control, Hand pulling, screen grain, seeds, crop rotation.

Crab-grass. finger-grass: (A); (Syntherisima Sanguinalis); Fam., Grass; Hab., Gardens and cultivated fields; N. H., Europe; Char., Many small seeds. Takes root at joints; Control, Hand pulling, burn plants, burn stubblefields.

Creeping Mallow, Cheeseweed: (P); (Malva rotundifolia); Fam., Mallow; Hab., Dooryards, waste places, gardens; N. H., Europe and Western Asia; Char., Very long root. Stands drought; Control, Thorough cultivation, digging out by root.

Curled dock, yellow: (P); (Rumex Crispus); Fam., Buckwheat; Hab., Waste places, old pastures; N. H., Europe and Asia; Char., Long, thick root. Many seeds. Control, Cutting root several inches below surface before seeds ripen.

Dandelion: (P); (Taraxacum taraxacum); Fam., Chicory; Hab., Lawns, pastures, roadsides; N. H., Europe, Asia, and probably North America; Char., Long, thick root. Many seeds, widely distributed by wind. Blossoms all year. Control, cutting root far below surface before plant goes to seed.

Field bindweed, small bindweed: (P); (Convolulus arvensis); Fam., Morning Glory; Hab., Cultivated fields; N. H., Europe and Asia; Char., Spreading by rootstocks which form buds and start

new plants; Control, Cutting tip frequently during the entire summer. Smothering with paper or straw.

Field sorrel, horse sorrel: (P); (Rumex acetosa); Fam., Buckwheat; Hab., Pastures, meadows, cultivated fields; N. H., Europe; Char., Spreading by running rootstocks. Numerous seeds. Control, Crowding out with clover and grasses. Lime on soil to enable clover to grow well.

Foxtail, yellow: (A); Pigeon grass; (Ixophorus glaucus); Fam., Grass; Hab., Garden, cultivated fields; N. H., Europe; Char., Many seeds retaining vitality for years. Send out new stems when cut off. Strong fibrous roots. Control, Mowing and burning stubblefields. In garden pulling out by roots when soil is soft after a rain.

Foxtail, green: (A); (Ixophorus viridis); Fam., Grass; Hab., Gardens, cultivated fields; N. H., Europe; Char., Same as above. Control, Same as yellow foxtail.

Horse nettle: (P); (Solanum Carolinense); Fam., Potato; Hab., Cultivated fields, pastures; N. H., United States and Canada; Char., Numerous seeds. Spreads also by a strong rootstock. Exceedingly hardy; Control, Cutting off close to ground and salting.

Horseweed, colt's tail: (A); (Laptilon Canadense); Fam., Thistle; Hab., Pastures, roadsides, waste places, gardens; N. H., North America and South America; Char., Many seeds with pappus distributed by wind; Control, Cutting and burning. Pulling before seeds ripen.

Jimson-weed: (A); (Datura Stromonium); Fam., Potato; Hab., Waste places, barnyards; N. H., Tropical Asia; Char., Many seeds, Hardy; Control, Pulling when young. Cultivation.

Knotgrass, doorweed: (A); (Polygonum aviculare); Fam., Buckwheat; Hab., Yards, roadsides, along walks; N. H., North America, Europe, and Asia; Char., Spreading close to ground, not easily injured by trampling; Control, Pulling or cutting before seeds ripen.

Lamb's quarters, goosefoot: (A); (Chenopodium Album); Fam., Goosefoot; Hab., Gardens, cultivated fields; N. H., Europe and Asia; Char., Many seeds, produces new stems when cut off; Control, Pulling or hoeing before seeds ripen. Thorough cultivation.

Lamb's quarters, city goosefoot: (A); (Chenepodium urbicum); Fam., Goosefoot; Hab., Gardens, along walks, waste places; N. H., Europe; Char., Same as last and control the same.

Lettuce, wild, prickly lettuce: (A); (Lactuca Scariola); Fam., Chicory; Hab., Waste places, gardens, old fields; N. H., Europe; Char., Many seeds with pappus, scattered by the wind. Prickles protect it from animals. Plants that start late in summer live over winter; Control, Early cultivation or hoeing in spring to kill winter plants. Cutting and burning before seeding.

Morning-glory, wild, hedge bindweed: (P); (Convolvulus sepium); Fam., Morning-glory; Hab., Cultivated fields, fence rows; N. H., North America, Europe and Asia; Char., Spreads by seeds and running rootstocks; Control, Cultivating every ten days or two weeks all summer, in small plots, smothering by tar paper.

Milkweed: (P); (Asclepias syriaca); Fam., Milkweed; Hab., Cultivated fields, meadows, pastures; N. H., All parts of United States; Char., Seeds with pappus widely scattered by wind. Spreads also by deep running rootstock; Control; Repeated cutting during the entire summer, continued for two years.

Mullein: (B); (Verbascum thapsus); Fam., Figwort; Hab., Pastures, roadsides; N. H., Europe; Char., Many small seeds which retain vitality for years. Rosette of thick leaves close to ground, well protected; Control, Cutting off rosette below crown in fall or early spring.

Mustard, wild, charlock: (A); (Brassica arvensis); Fam., Mustard; Hab., Grain fields, especially oats, meadows; N. H., Europe; Char., Many seeds which mix with grain when threshed; Control, Burning stubble or harrowing to start seeds. Plowing under in fall. Pasture with sheep.

Old witch grass, tickle grass: (A); (Panicum capillare); Fam., Grass; Hab., Gardens, cultivated fields, stubblefield; N. H., Southern Canada and all of United States; Char., Many seeds, rapid grower. Plant breaks off in the fall near the ground; Control, mowing and burning.

Parsnip, wild: (B); (Pastinaca sativa); Fam., Parsley; Hab., Waste places, roadsides; Char., Strong root, hardy plant, many seeds; Control, Cutting out below crown first-year plants. Mowing and burning second year.

Plantain: (P); (Plantago major); Fam., Plantain; Hab., Lawns, roadsides, pastures; N. H., Europe; Char., Many seeds, rosette of leaves close to ground, stands trampling; Control, In yard, cutting below surface. In pastures, crowding out with clover.

Peppergrass, tongue-grass: (A); (Lepidium Virginicum); Fam.,

Mustard; Hab., Dooryards, waste places, gardens, meadows; N. H., Canada and United States; Char., Many seeds, plants start in the fall and live over winter; Control, Pull up by roots in lawns. Thorough cultivation in fields.

Pigweed, careless weed: (A); (Amaranthus retroflexus); Fam., Goosefoot; Hab., Gardens, cultivated fields; N. H., Tropical America; Char., Numerous small seeds. Send out new stems that produce seed when cut off near the ground. Very hardy; Control, Pulling before seeds ripen. Burning in fall all the plants that have gone to seed.

Pigweed, red-stemmed: (A); (Amaranthus hybridus); Fam., Goosefoot; Hab., Garden, fields; N. H., Tropical America; Char., Same as above. Control, Same.

Purslane, pussley: (A); (Portulaca oleraceus); Fam., Purslane; Hab., Gardens, cultivated fields; N. H., Southern United States, and Tropical America; Char., Blossoms and bears seed all summer. Seeds many, plant very juicy. Can stand drought; Control, Pulling out when young, drying and burning, or feeding to hogs.

Pungent meadow-grass: (A); (Eragrostis major); Fam., Grass; Hab., Gardens, waste places; N. H., Europe; Char., Many seeds, strong roots; Control, Hoe or plow out before seeding.

Quack-grass, couch-grass: (P); (Agropyron repens); Fam., Grass; Hab., Grain fields, lawns, gardens; N. H., Europe; Char., Strong rootstock that spreads rapidly. Clings so firmly in soil that it cannot be pulled up; Control, Plow in fall, harrow or rake, pile and burn plants. Two plowings may be necessary.

Ragweed, common: (Ambrosia artemisiaefolia); Fam., Ragweed; Hab., Stubblefield, cornfield, pastures, gardens; N. H., North America, South America; Char., Many seeds. Can grow and mature seeds late in summer. Can stand dry weather; Control, Working and burning stubble. Early fall plowing.

Ragweed, horsewood: (A); (Ambrosia trifida); Fam., Ragweed; Hab., Roadsides, along streams, fence corners; N. H., United States and Canada; Char., Many seeds carried by birds, not a very bad weed; Control, Pulling before seeding. Burning stubble. Pasturing with sheep.

Shepherd's purse: (A); (Bursa bursa pastoris); Fam., Mustard; Hab., Waste places, gardens, lawns; N. H., Europe; Char., Plants that start late in the summer live over winter and produce seeds early. Flowers all summer; Control, Hand pulling from lawns. Fall plowing in gardens and fields.

Sow-thistle: (A); (Sonchus oleraceus); Fam., Chicory; Hab., Waste places, roadsides, fence corners; N. H., Europe, Asia; Char., Many seeds with pappus, distributed by the wind; Control, Cutting while young, burning mature plants.

Spanish needle, bur marigold: (A); (Bidens connata); Fam., Thistle; Hab., Low regions in fields and pastures; N. H., United States and Canada; Char., Seeds with bristles that stick to animals and clothing; Control, Thorough cultivation, cutting before seeds ripen.

Smartweed, spotted smartweed: (A); (Polygonium persicaria); Fam., Buckwheat; Hab., Gardens, cultivated fields, especially low regions; N. H., Europe; Char., Seeds many, distributed in grain; Control, Cutting before seeds ripen, burning stubble, pulling or hoeing in gardens.

Spurge, spotted: (A); (Euphorbia maculata); Fam., Spurge; Hab., Gardens, cultivated fields, roadsides; N. H., North America; Char., Many seeds. Grows prostrate forming a mat on the ground. Control, Hoeing or pulling, through cultivation.

Spurge, upright, spotted spurge: (A); (Euphorbia nutens); Fam., Spurge; Hab., Gardens, cultivated fields, roadsides; N. H., North America; Char., Many seeds. Same as above but stands erect instead of spreading on ground; Control, Hoeing or pulling; thorough cultivation.

Spreading orache: (A); (Atriplex patula); Fam., Goosefoot; Hab., Roadsides, along walks, waste places; N. H., Europe and Asia; Char., Many seeds, rapid grower, many branches; Control, Pulling or hoeing before flowers appear.

Squirrel-grass, wild barley: (P); (Hordeum jubatum); Fam., Grass; Hab., Roadsides, fence corners, meadows; N. H., Canada and Northern United States; Char., Long beards, seeds scattered by wind and water; Control, Pulling, cutting or hoeing before seeds ripen.

Tumbleweed: (A); (Amaranthus graecizans); Fam., Amaranth; Hab., Grain fields, old fields, roadsides; N. H., Tropical America; Char., Many branches forming a round head which breaks off close to the ground, rolls over and over scattering the many small seeds; Control, Burning the mature weeds in the fall. Pulling or hoeing before seeding.

Thistle, pasture or bull thistle: (B); (Carduus lanceolatus); Fam., Thistle; Hab., Pastures, roadsides; N. H., Europe and Asia;

Char., Deep root, many sharp spines, seeds scattered by wind; Control, Cutting off root well below the crown.

Vervain blue, wild hysop: (P); (Verbena Castata); Fam., Vervain; Hab., Pastures, meadows, waste places; N. H., Southern Canada and United States; Char., Hardy, stands drought, not a very bad weed; Control, Cultivation and mowing.

White top, daisy fleabane: (A); (Erigeron annuus); Fam., Thistle; Hab., Meadows, pastures, oat fields; N. H., Europe; Hab., Plants started in the fall live over winter and blossom early. Many seeds; Control, If very abundant in meadows plow under and plant corn. Pull out by roots.

Wild buckwheat, black bindweed: (A); (Polygonum convolvulus); Fam., Buckwheat; Hab., Cornfield, grain, fence rows, gardens; N. H., Asia. Brought here from Europe; Char., Climb or twine around corn and wheat. Many seeds; Control, Early fall plowing and harrowing. Pulling or mowing and burning before seeds ripen.

Wild sweet potato: (P) (Ipomea pandurata); Fam., Morning-glory; Hab., Cultivated fields, meadows; N. H., Canada and United States; Char., Thick, fleshy roots that send up new plants. Many seeds; Control, Deep cutting, salting, mowing and burning tops several times during the season.

Yarrow, milfoil: (P); (Achillea millefolium); Fam., Thistle; Hab., Pastures, roadsides, lawns; N. H., United States, Europe, and Asia; Char., Spreads by horizontal rootstocks, very hardy; Control, Pulling, cutting and burning.

CHAPTER IV

TREE STUDIES

Material. Trees of the neighborhood, leaves, twigs, fruit and seeds for indoor study and for charts and booklets.

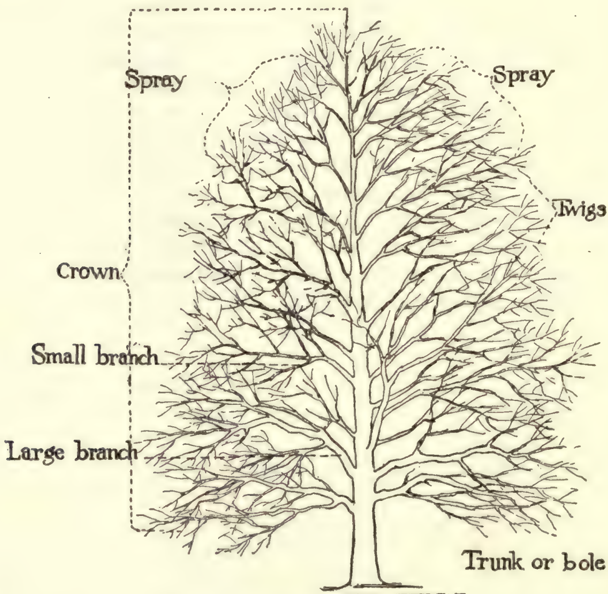


Fig. 16. The parts of a tree.

Study. How many trees in your neighborhood do you know? If you do not know most of them set

about learning them. Do not be satisfied simply to distinguish an oak from a maple or a pine from a fir, but learn the exact species of every tree in your community.

Select a special tree for study. Stand a short distance from it and name all the parts you can see. If you do not know the names, consult Fig. 16.

What is the shape of the crown? Is the top rounded, flat or pointed? Is it dense or open? What

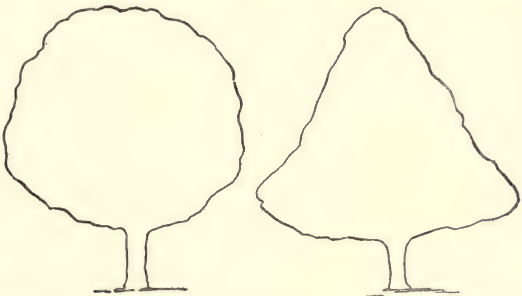


Fig. 17. Tree forms: spherical and broadly conical.

is the character of the branching? Does the trunk break up into a number of branches or extend unbroken to the top? Note the twigs and determine whether they are thick and erect, slender and drooping, few or many. Examine the bole; what is its color? Compare with the branches and twigs. Describe the bark. Is it smooth, furrowed or scaly? Are the furrows or fissures deep or shallow? Do they extend up and down or around the trunk?

How do the ridges compare with the furrows as to width? Look at two or three different species of trees until you are certain that each has its own bark pattern. Look also for differences in shape and branching. Stand at some distance from the trees and make an outline sketch of the different type forms. Consult Figs. 17 and 18. Compare the forms of trees standing close together with those of the same species standing alone. To what extent are

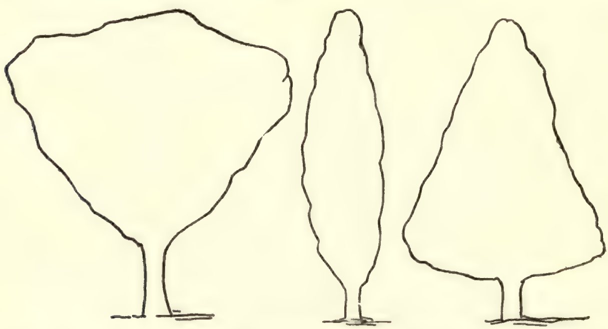


Fig. 18. Tree forms: inverted cone, columnar, and conical.

the roots visible above the ground? Compare different trees with reference to this characteristic.

Leaves. Stand under a trees and look up. Where are the leaves most numerous? To what extent do they overlap? Are they simple or compound? Compare the upper and under sides. What are the parts of one leaf? See Fig. 19. What form does the petiole take where it is attached to the twig?

How are the leaves arranged on the stem with reference to each other? What relation can you see between the petiole and the large veins? Hold the leaf between you and the light to see how numerous the small veins are. Study the leaves on one twig and note differences as to size, shape, and length of petiole. Can you see any advantage to the leaves in the different sizes of the blades and the different lengths of petioles? If you have a twig indoors lay it down upon your desk allowing the leaves to assume a natural position. How does this help you to solve the problem?

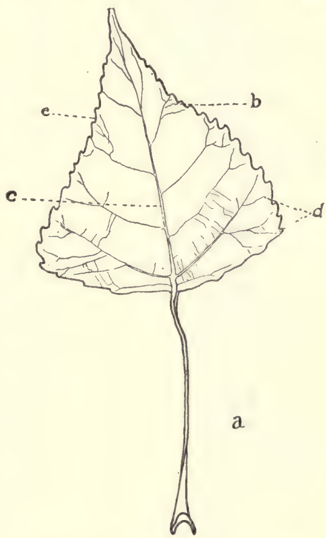


Fig. 19. Parts of a leaf: a, Petiole; b, Blade; c, Midrib; d, Veins; e, Margin.

Compare leaves of different species of the same family, as those of different maples, oaks or elms, and determine what characteristics are similar and what are different. Make a collection of all the different types of leaves you can find.

Watch the trees frequently for a number of weeks to find out what they do to get ready for the winter season of inaction. What different colors do you

find? What color is most prominent? What trees have the most brilliant reds? Which ones are chiefly yellow? Which dull purple or brown? When the leaves have fallen, examine the spots on the twigs from which they dropped and try to decide what caused them to drop off.

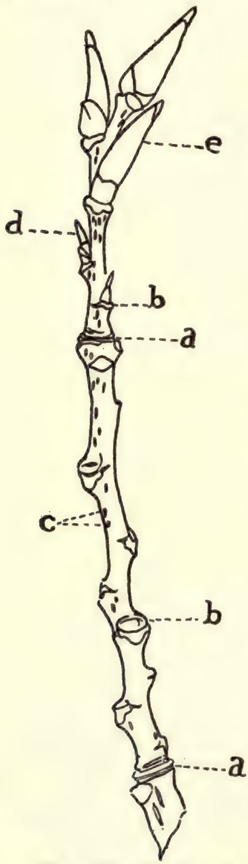


Fig. 20. Parts of a twig: a, Ring scar; b, Leaf scars; c, Lenticles; d, Leaf bud; e, Flower bud.

Twigs. Look carefully at a twig and make a list of everything that you see. This study is best made after the leaves have fallen. See Fig. 20. How can you tell exactly where the leaves were located? Describe a leaf scar. Compare the scars on the older parts of the twigs or branch with those of this year.

Classify the buds as to position on the twigs and their relation to each other. How do they differ as to shape and size? What will each kind of bud produce? If you do not know, wait until spring to solve the problem. Examine a bud very closely and describe what you see. What is on the outside? The inside? What is the

value of the scales, the downy covering, or sticky secretion?

How can you tell what part of the twig grew this year? What makes this ring scar? How many years' growth does your twig represent?

Compare the twigs of a number of different trees with reference to the length of growth in one season, the arrangement of buds, and the shape of leaf scars.

Fruit and seed. Make a list of all the trees you can find that retain their fruit or seeds during the fall or after the leaves have fallen. Describe the different kinds of fruit. How many of them have special adaptations for dissemination? Open up the fruit in each case and find the seeds.

Make a list of everything you have discovered that deciduous trees do to get ready for the winter rest and for renewal of growth in the spring.

You will find the following outline helpful in keeping a record of your tree studies. Do not think that every item must be put in with your first observation. You may have to wait months to complete the record.

OUTLINE FOR TREE STUDY

1. *Name*:
2. *Shape*:—conical, broad conical, narrow conical, spherical, columnar, inverted cone.
3. *Method of branching*:—(a) excurrent. (Main stem may be

traced from ground to top of tree); (b) deliquescent. (Main stem breaks up into branches.)

4. *Twigs*:—erect, drooping, slender, thick, graceful, stiff, etc.

5. *Trunk or bole*:—color; surface, smooth, rough, scaly, furrows or fissures, deep or shallow, ridges wide or narrow.

6. *Leaves*:—arrangement, opposite or alternate; simple or compound; if compound, number of leaflets; oddly pinnate, evenly pinnate; special characteristics; shape, color, roughness, smoothness, etc.

7. *Flowers*:—date of flowering, kind: (a) perfect, both stamens and pistil in one flower; (b) staminate, a flower with stamens and no pistil; (c) pistillate, one with pistil and no stamens.

8. *Fruit*:—date of maturing, kind. *Seeds*:—kind.

9. *Buds*:—arrangement, opposite or alternate, shape, color, scales.

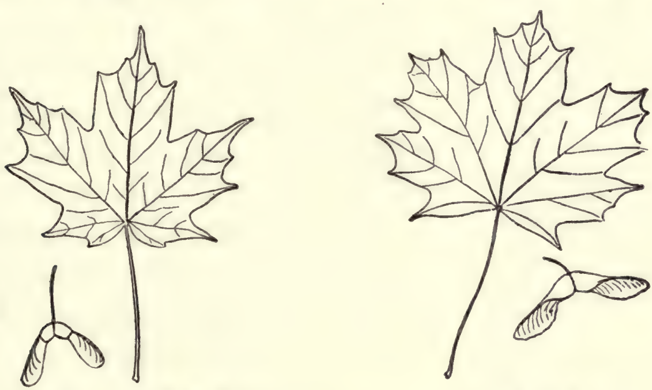
10. *Remarks*:—value of tree for ornamental purposes. Other uses, etc.

Charts and booklets. Make a set of tree charts, or booklets. Each individual tree species represented on a chart or page should contain a leaf, the fruit, seeds, and a twig in winter condition, a small bit of bark and when possible a section of wood. Cardboard or any stiff paper should be used, and the specimens sewed on rather than pasted. In regions where there are few trees, leaf charts may be made. Group charts or pages to show family relationship; that is, put together all the oaks, maples, pines, etc.

Discussion. We may group our trees into broad-leaf and narrow-leaf trees. The narrow leaves are usually called needles. In the northern and central states all broad-leaf trees are deciduous; that is, they

drop all of their leaves each year. Almost all of the needle-leaf trees are evergreen. A few, however, the larch and cypress, drop their leaves in the fall. Some of the broad-leaf trees in the South retain their leaves during the winter.

The shape of a tree depends largely upon the method of branching and the number and character of the twigs. A tree whose trunk breaks up into



Sugar or Rock Maple *Norway Maple*

Fig. 21. Sugar or Rock Maple and Norway Maple.

a number of branches has deliquescent branching; one whose trunk extends up through the crown has excurrent branching.

Some trees, as the maple, elm, and oak, have simple leaves. Each blade is in one piece, although the margin may be notched or lobed. Others like the walnut, hickory and ash, have compound leaves;

that is, the blade is divided into a number of small leaves called leaflets. If the leaf has an odd number of leaflets it is said to be oddly pinnate; if it has an even number it is evenly pinnate.

As autumn advances you notice that the leaves change color. This change comes because the leaves are ceasing to work. Their chief work is to manufacture starch and other foods. As this work slowly stops the green coloring matter changes to yellow. The bright reds and the dull purples are produced by certain chemical changes that take place in the tissues of the dying leaf. Autumn coloration then simply tells you that the trees have shut down their starch factories and are getting ready for the season of rest. You sometimes hear people say that frost is the cause of autumn coloration and the dropping of the leaves. You can readily see from what you have learned that this cannot be strictly true. The fact is that some years the leaves are a brilliant color before we

Fig. 22. A compound leaf showing seven leaflets.

have any frost. Early cold weather accompanied by frost probably causes the leaves to stop their work earlier in the season, and that is all that frost has to do with it. Sometimes a heavy freeze comes while the leaves on some trees are still active and full of moisture. In that case they are simply killed, which is shown by their withering.

The dropping of leaves comes, too, with the cessation of work. As you looked at a twig from which the leaves had fallen, you found that no wound was left, but that a layer of skin or thin bark had grown upon the twig under the petiole. This layer severs the petiole from the twig. The leaf may cling for a time by the fibres, but a slight breeze, the weight of raindrops, or even its own weight finally takes it off. The fibers of some trees, as certain oaks, are so firmly attached that the dry, dead leaves remain on the twigs all winter.

In some ways the buds are the most important things that are found on the twigs. Do you know how early each season they make their appearance? You will find this an interesting problem to solve by observation next spring and summer.

The scales, downy coverings, and sticky secretions protect the buds from mechanical injuries, but their most important use is to prevent the evaporation of water. During the winter very little moisture is

taken into the tree through the roots. If the small leaves and flowers in the buds were not protected in some way, they would dry out and die.

If you watch the buds open in the spring, you will find that usually the large ones on the twigs produce flowers, while the smaller ones produce a twig with leaves. On some trees the leaf and flower buds are combined. The lateral buds produce new twigs and afterwards become the branches. The terminal buds lengthen the branches. When the buds open the scales drop leaving the ring scars. These scars not only tell you where the buds were but also that the scales are arranged in a series one above the other.

The dots called len′ti-cels are tiny openings in the bark, which when the twig is young allow the entrance of air and probably the exit of waste products and water.

Winter study. Do not stop the observation of trees during the winter. This is one of the best seasons to learn the typical forms, the branching, color, and especially the twig and bud characteristics. If you have never looked closely at trees during this season, you will be surprised to find how individual, how interesting, and how beautiful they are.

WINTER STUDIES

CHAPTER V

SOILS

Material. Soil from gardens, fields and excavations; a collection of pebbles, gravel, sand, silt and clay; apparatus described in connection with experiments.

Examine carefully a small quantity of soil that has been taken from a cultivated field or a garden. Write out a list of everything that you find.

Experiment. Place some of the soil in a large iron spoon and hold it over the flame of an alcohol lamp or gas burner. Heat it, stirring occasionally. What happens? Set it away to cool and then examine it again. What changes have taken place? Is the color lighter or darker? What part burned up? What is the material that is left? Before you try to answer fully the last question examine a small portion of sand, silt and clay. Look at each with a hand lens. Which has the finest particles? What do you find in the sand that is not present in the silt or clay? Take a pinch of each between your thumb and finger and rub them. How does the sand feel? The silt? The

clay? Silt is often spoken of as clay. The yellow clay of the Middle West is silt.

Heat a small portion of clay and of silt just as you did the garden soil. Describe what takes place. After they have cooled compare each with the burned garden soil. Which one resembles it most? Can you decide now what you got from burning the garden soil?

Explanation. You no doubt found small bits of roots and other parts of half-decayed plants in your sample of soil. When you heated it the plant particles burned up and you had left what may be called the foundation soil. What this foundation soil is depends wholly upon the region from which it was taken. It may be almost pure sand, pure silt, or some kind of clay. The probabilities are that it is a mixture of sand and silt or sand and clay. In any case the soil mixture including the part that burned is called loam. If it has a large per cent of sand it is sandy loam; if there is much more silt than sand it is silt loan; and if clay is the most prominent part it is clay loam.

The part that burned, the organic matter, is called humus. Leaf mold in the woods, the soft decaying material under layers of pine needles, the remains of an old straw stack, or well rotted stable manure, are all types of humus.

You can find out by experiment something more about the different kinds of soil.

Experiment. Pour the same amount of water into each of three tumblers. Stir into one a tablespoonful of sand, into another clay, and into the third silt. Which settles to the bottom first? Keep a record of the time that it takes for the water to become clear in each glass. What does this tell you about the size of the particles of each kind of soil? Which will remain suspended longer in the water, coarse or fine particles?

Experiment. Put a spoonful of your garden loam into a glass of water and stir as before. How does it behave? After it has all settled, look through the glass to determine whether or not the soil shows any layers of coarse and fine material.

Explanation. These experiments show that different soils differ greatly with reference to the size of the particles. You probably found that the sand settled to the bottom before the silt or clay. This is because the particles are larger and heavier. Different sands vary; some are coarse, some fine. Silt is much finer than sand, but not as fine as clay. Different silts and clays vary just as sands do. Some are very fine, others are coarse.

If your garden loam is a mixture of sand and clay or silt, you probably found that it had settled in

layers, the sand in the bottom and the clay or silt on top. You probably found, too, that some of the humus remained floating in the water long after all the rest had settled.

Origin of soil. What is the origin of soil? Perhaps you have already found out something about this from your geography; if not, you can think out part of the answer for yourself.

Collect from the bed of a stream, the shore of a lake or wherever you can find them, a number of pebbles.

Examine the pebbles you have brought in. Place into groups those that seem to be of the same kind of rock. How many different groups have you? Do you find any that seem to be made of more than one kind of rock? With a nail or other sharp instrument scratch the different kinds. What do you determine as to their relative hardness?

Compare your pebbles as to shape. Is there any way to account for the fact that some are round while others are flat?

Formation of pebbles. With a hammer break some of the larger stones into small pieces. How do the pieces differ from the pebbles?

Experiment. Can you think what has made the pebbles so smooth? Fill a pint milk bottle about one-third full of the broken bits of rock. Now pour in

water until the rock fragments are covered. Place a cover on the bottle or hold your hand over the top and shake vigorously. As the pieces of rock strike against each other what happens? Continue shaking them, off and on, for days. When you allow the bottle to stand until the water is clear what do you find in the bottom?

Explain why you find so many pebbles along streams, and on the shores of lakes and rivers. If you should follow a stream to its source in hills or mountains, would you find as many small, smooth pebbles and stones there? Why?

Experiment. Other agents that help to break up rocks. Break up a piece of limestone or marble. Put the pieces into a bottle. Into a half pint of water put a tablespoonful of hydrocholoric acid and pour over the pieces of stone. Shake thoroughly. Describe what happens.

Discussion. From your observation and study you have probably come to the conclusion that pebbles, gravel, sand, silt and clay are all forms of broken and ground up rock. Indeed, if you go back far enough in the history of the earth you must think of a time ages and ages ago when there was no soil on the earth, nothing but solid rock, wrinkled and jagged with here and there huge broken pieces. Little by little various agents ground up the solid rock into finer and finer

particles. One of the chief agents that helped to do this was changes of temperature. When rocks are heated by the sun they expand. When cooled they contract. If the contraction takes place suddenly, the rocks are likely to crack open.

Freezing is another important soil-making agent. Water from rains or melting snow gets into cracks and crevices of rocks and when it freezes it expands and breaks the rocks. In the same way our soil in fields and gardens is made finer during the winter by thawing and freezing. We have already found by experiment that the rubbing together of stones through the action of water is an important soil-making agency.

If you were to visit a stream whose source is in mountainous regions, you would find near the source large pieces of rocks that have been broken from the hillsides and bluffs and have fallen into the stream. These pieces are the beginnings of pebbles. They are broken into smaller and smaller pieces by tumbling over each other, by the action of frost, and by rubbing together as they move farther down the stream. After a long, long time the rough edges are worn off and nothing is left but smooth stones or pebbles. The worn off particles settle to the bottom and form the sand or mud in the bed of the stream.

The pebbles found on the shores of lakes and seas are made by the dashing of the waves back and forth

on the beach. The pieces of rock roll against each other and the edges are worn off. Pebbles found along shores are usually round, while those in streams are flat.

The work of glaciers, the great ice sheets that moved slowly over a great part of our country thousands of years ago, accounts for much of our fine silt and clay. The great boulders and pebbles that we find scattered here and there over the prairies are also due to glaciers. If you look closely you may find scratches on some of these stones. As the glaciers moved slowly over the land they picked up pieces of broken rock and pebbles and carried them along. Some of them passed over other rocks and pebbles and left deep scars on them.

Your experiment with the acid and limestone shows how rocks may be dissolved by chemicals carried in solution in water. Plants themselves aid in making soil. Certain plants that are called lichens will grow upon solid rock. As they grow they give out an acid that eats into the rock slowly softening it and changing it into fine soil.

Broken up rocks alone do not make soil. You found in the soil of the garden and fields partially decayed vegetation or humus. Humus is an essential part of soil and is necessary to plant life. It is produced by parts of plants slowly decaying in the soil where little

oxygen can reach them. It may be increased in any cultivated field by plowing under stubble, corn stalks, grasses, clover, etc. Humus is dark in color, so a black soil usually indicates an abundance of humus.

CHAPTER VI

WATER IN SOIL

Material. Samples of the different kinds of soil studied in the last chapter; five straight lamp chimneys; a rack or jars to hold them; tumblers.

Source of water in the soil. Water in the soil is quite as necessary for plant growth as minerals from the rock particles and the humus. Rain is the source of all soil water; if you watch the rain during a shower you will observe that some of it runs off the ground, some stands in puddles, and some sinks into the earth.

Ground water. All the water that goes into the earth is called ground water.

Experiment. To determine what becomes of the ground water. Place a layer of pebbles in the bottom of a tumbler, cover with a piece of cloth and on top of this place dry garden soil until it stands within an inch of the top. Firm the soil by striking the glass on the table. Pour some water on the soil a little at a time and watch to see what it does. Continue to pour until water stands in the spaces among the pebbles in the bottom of the glass.

Explanation. When rain falls upon the ground it does just what the water in the glass did. It percolates slowly downward through the soil till it is stopped by solid rock or by a layer of clay or by soil already full of water. Now if rain continues the water will fill all the spaces among the tiny particles of soil until it finally stands on the surface of the ground, for, while you cannot see them, soil is made up of fine particles. Water that is found in the spaces among the particles of soil is called free water. Plants do not use free water.

The level at which free water stands in the soil is called the ground water level or the water-table. Perhaps you noticed when you poured water upon the dry soil in your experiment that bubbles of air came out as the water went in. When the spaces are not filled with water they are full of air.

Capillary water. Examine some soil that is slightly moist. This does not contain free water.

Experiment. Where is the water in this moist soil? Tie a piece of thin cloth loosely over a tumbler; place two or three small, smooth pebbles close together on the top of the cloth. Pour some water over the pebbles and let it drain down into the tumbler. Now examine the pebbles. Describe what took place. Where is the water in relation to the pebbles?

Explanation. The water that remains clinging to

the pebbles is called film water because it forms a film around the pebbles. In the same way moist earth has a film of water around each tiny particle of soil. This is known as capillary water. It is this water that plants use. The free water must be drained off to give the roots a chance to get the capillary water.

Experiment. Drainage. Tie a piece of cloth firmly over the tops of each of five lamp chimneys. Put sand into one, clay or silt in another, and loam in another. In the fourth put a mixture of half sand and half humus, either well rotted manure or leaf mold. Into the last put a mixture of half clay and half humus. Arrange a rack for the chimneys or stand each one in a jar. Measure a definite amount of water and pour it slowly into the sand. Note the number of minutes required for the water to pass through and drip into a dish or the jar. Keep a record of the amount of water you pour in. Do the same with all the other chimneys. Measure the amount of free water that drips from each. Through which soil does the water drain most readily? Which one takes longest for the water to pass through? Which soil retains the greater amount of water? What is the effect of putting humus into sand? Of putting it into clay?

Explanation. Your experiment shows that water passes rapidly through sand but slowly through silt

or clay. Humus in sand makes it retain more water and drain less rapidly, while humus in clay has the opposite effect. Humus then improves both of these soils.

What method is used in your neighborhood to drain the soil? If you live in the country find out how your farm is drained. You may find an open ditch or an underdrain.

Drainage is of advantage for several reasons: 1. The ground water level is lowered so that the roots of plants go deeper into the ground. A deep root system is of value to plants during the dry season. 2. It gives an opportunity for air to reach and fill the spaces near the surface, and plants need air as well as water. 3. A well drained soil warms earlier in the spring. Do you know why? A soil full of water uses up heat in evaporating the moisture.

Underdrainage, where it can be practiced, is more satisfactory than the open ditch. It does not waste land since the soil over the tile may be cultivated. It drains to a greater depth and thus makes it possible for the plants to produce a deeper root system. See Fig. 23.

The value of drainage is not generally understood. Where the land is not at all level, or where the soil to a considerable depth is composed of sand or gravel, drainage is not likely to be important, because the

excess water runs away over the surface or settles to a depth below the level of ordinary plant roots.

On the other hand, where the land is very low, or very level over a considerable area, the soil is likely to be saturated with water to a level somewhere near the surface. For example, if one digs a hole he usually has not to go down very far before he finds that the water flows in and stands at a certain level in the

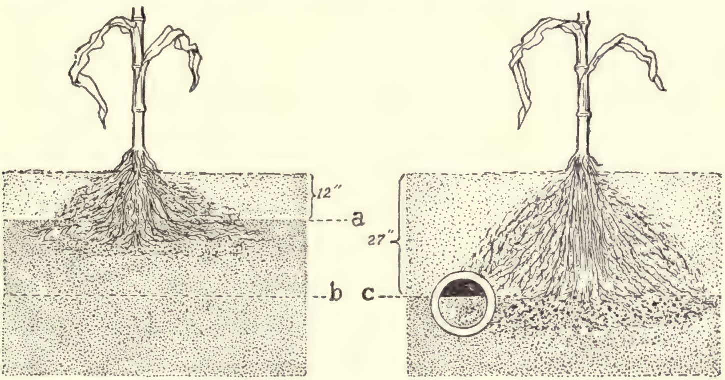


Fig. 23. Showing one important effect of drainage.

hole. This shows the level at which the soil at that particular place is saturated with water.

In undrained land this water level varies in distance below the surface of the soil according to whether the season is dry or there is much rainfall. During the wet season it is likely to be very near the surface, perhaps not more than six, eight, or twelve inches. See line *a* in Fig. 23. Plant roots do not thrive below

this water level, because they cannot get air. Moreover, when the soil is thus saturated for a considerable length of time it is cold and is likely to become sour. Plants growing on soil of this kind do not thrive. They commonly look weak and the leaves turn yellow. Then if there is a period of drought the water level may be considerably lowered in a short time. See line *b* in the diagram. In such a case the plant roots are not only left away above the water line, but the soil is likely to bake and harden.

The other part of the diagram indicates that where the soil is drained the water level is likely to be maintained at nearly all times at the level of the drain. See line *c*. Under these conditions the plant roots extend themselves far enough down in the soil to get all the moisture they need. In addition to this the soil above the water level in drained land never bakes or hardens; that is, it is always open and porous. The plant roots grow more freely in it and the moisture is drawn upward above the water level by the capillary action in the soil quite uniformly at all times.

Irrigation. You may live in a region where irrigation is necessary. All through the western states there are large tracts where the annual rainfall is not sufficient for the growth of plants. Here water is brought from mountain streams or lakes through tunnels or aqueducts. Usually small ditches several

rods apart extend through the fields or orchards. The owner controls the supply by opening a sluice and allowing the water to run into the ditches and flood the fields.

CHAPTER VII

SOIL WATER AND PLANTS

Material. Seeds of oats, corn, radishes or other plants; plates or boxes, a growing plant in a pot.

Experiment. Root-hairs. You know that plants cannot live without water and you will be interested in learning how they get water from the soil. Place some seeds of radishes, oats, wheat, or corn on a plate of moist sand or soil. Press them slightly into the soil but do not cover. Turn a plate over them to keep the moisture in. Watch them from day to day. Do not allow the soil to dry. Describe the roots and root-hairs. On what part of the roots are the hairs most numerous? On what part are there no hairs? Place one of the plants on a piece of paper on your desk for a short time. What happens to the hairs? Watch the plants for several days to see whether any of the hairs wither and die and whether new ones continue to appear. (Refer to Fig. 8, page 33.)

Explanation. You found the delicate hairs growing all around the young roots. If these roots were covered with soil, the root-hairs would penetrate the spaces between the soil particles and come in close

contact with the films of water. The film or capillary water passes through the thin walls of the root-hairs. You may think this a slow process and it is, but when you consider the thousands of root-hairs on all the small roots of the growing plants you realize that together they can take in a vast quantity of water. The process by which the water passes through the thin membranes of the root-hair is called osmosis. The same process takes place in your own body when digested food is absorbed by tiny capillaries which surround the digestive tract, and is carried into the blood to be distributed to all parts of the body.

The water that plants take into their roots is not pure water but has in it certain minerals that the plants use in their growth.

Experiment. To distinguish soluble and insoluble substances.

1. Into a half glass of warm water slowly stir some fine salt. Continue to put in salt until it begins to settle to the bottom of the glass. What became of the salt that disappeared? Drain off the clear water, put it into a pan and place it on a stove or over an alcohol lamp till it is all evaporated. What is left in the pan? How is salt commonly obtained? Make the same experiment with sugar and saltpetre.

2. Into a half cup of water stir some chalk dust,

lime, or sulphur. Do any of these act as the salt and sugar did? How do you account for the difference?

Explanation. The salt disappeared because it was dissolved by the water and changed into a liquid. The chalk or sulphur will not dissolve in water so it remains in the solid form. A substance that dissolves as the salt did is said to be soluble in water. Chalk and sulphur are insoluble in water. You can see from this that all soil minerals that enter the root-hairs must be soluble in water.

All seed plants need ten different elements if they are to grow and produce fruit. Seven of these are obtained from the soil. They are nitrogen, phosphorus, potassium, calcium, sulphur, iron and magnesium. The last three are so abundant in soils and are used in such small quantities that we do not need to concern ourselves about them. Calcium is abundant in most soils but is lacking in a few regions. The first three elements, nitrogen, phosphorus, and potassium, are not abundant in most soils and are used in comparatively large quantities; hence they are frequently lacking in fields that have crops growing in them year after year. When we speak of "worn out soil," we usually mean that it lacks one or two of these elements.

Good farmers and gardeners try to keep their soil fertile by the use of fertilizers, by plowing under

plenty of vegetation to make humus, and by good tillage to insure a deep, rich, mellow soil-home for the plants.

The constant supply of water and mineral food. How to keep a constant supply of capillary water for the growing plants in regions that depend entirely upon rain is a problem of much interest.

Experiment. What are all the ways in which capillary water is taken from a field or garden in which plants are growing?

Fill a tumbler with moist soil. Invert over it another tumbler. Set it aside for twenty-four hours and then examine. What do you find on the inverted glass? Where did the moisture come from?

This shows that moist soil is constantly losing some of its moisture by evaporation. You know also that the plant itself is using up moisture. If this continues for days and there is no rain, the soil will become dry far below the surface.

Experiment. Capillarity. Tie a piece of cheese cloth over one end of a long glass tube, open at both ends, and fill it with dry soil. Stand the tube in a jar containing about an inch of water. What happens? Leave it for several days to determine how high the water will go in the soil. You can make some other èxperiments to illustrate the same principle. Tie a piece of an old towel to a pencil and

let the free end dip down into a jar which contains a small amount of water. What takes place?

The same thing takes place in the soil and in the towel. The water slowly rises. This is caused by what is known as capillarity or capillary attraction, and always occurs when liquids come in contact with fibrous or porous materials. The ordinary lamp wick which conveys oil from the bowl of the lamp to the top of the wick is a good example of capillary attraction.

Experiment. Capillarity found in different soils. Fill several glass tubes or the lamp chimneys used in the drainage experiment with different kinds of soil. Place the lower ends in water, and determine which soil lifts the water to the highest point by capillary attraction.

As water is used up by plants in the fields, more is constantly moving upward from the free water below. If the weather is very warm, much of the water that moves upward may be lost to the plants by evaporation, so another problem of the gardener and farmer is how to prevent this loss.

Experiment. Conserving soil moisture. Put equal amounts of soil into two pans of the same size. Firm the soil by gently jarring the pans upon the table. Pour equal amounts of water over each. Weigh each pan and set them side by side. Thoroughly stir the

upper inch and a half of soil in one pan every day keeping the layer on top very fine. Leave the other pan undisturbed. Weigh them at the end of three or four days, and again at the end of a week. Which one has lost more weight? Explain why the stirring of the soil prevents evaporation of water.

As long as the soil is left alone the water moves to the surface by capillarity and evaporates. Then cracks are likely to come in it which allow the air to penetrate to quite a depth and aid in evaporating the water. The stirring of the soil stops the flow of water to the surface. It is like breaking off the ends of tubes. This keeps the water in the soil. The layer of dry soil is called a soil mulch. You see how important it is to cultivate the top layer of soil in your garden or fields during hot dry weather.

Experiments. What becomes of all the water that plants take from the soil?

(a) Procure a small plant growing in a flower pot. Tie a piece of writing paper over the top of the pot. To do this slit the paper to the center, then cut out a round hole just the size of the plant stem and slip the paper around the plant. Place a glass jar over the plant and set it in the window. Look at it the next day. What has happened? Where did the moisture come from that settled upon the glass?

(b) Allow a plant growing in a flower pot to

remain a number of days without water. A small coleus or foliage plant is good for this experiment. What change occurs in the appearance of the plant? Pour water over the soil thoroughly soaking it. Keep a record of the number of minutes till the drooping leaves and stems revive. What now holds the plant rigid and erect?

Explanation. The moisture that gathered upon the glass in experiment (a) came from the leaves and stems of the plant. It was given out in the form of vapor and condensed upon the cool glass. It could not come from the soil because that was covered up. All living, working plants are constantly evaporating water. The process is called transpiration.

The second experiment tells you that one use of water in growing plants is to keep them rigid and erect. When too much water is evaporated compared to the amount taken in the plant wilts.

In order that plants may obtain from the soil all the water and minerals they require for their work, farmers and gardeners must treat the soil so that it will produce the best yield of crops now, and at the same time insure the production of good crops in all the years to come. To do this a number of things are necessary:

1. **Tillage.** This includes two processes, breaking or plowing, disking and harrowing, in preparation

for the seed, and cultivation when the crop is growing. Good tillage increases the depth of the soil. This means that the plowing must be deep. If only the upper three or four inches are turned over the surface of the soil will soon become depleted of its mineral plant-foods. Moreover, the lower layer of soil will become packed and sour and utterly unfit for the plant roots. Tillage also aids in the saving of moisture. How? Think of your experiment with soil mulch. It also loosens the soil so that it will hold more air and allow better ventilation. It kills out the weeds and thus prevents a loss of plant-foods to the crop. It turns under vegetation and thus increases the amount of humus in the soil.

2. **Drainage.** We have already seen that drainage is of advantage in lowering the ground water level and in keeping the soil surface open for the entrance of air.

3. **Rotation of crops.** Agriculturists are coming to believe more and more that growing the same kind of crop in a field year after year will result in absolute ruin to the soil. One reason for this is that certain crops use more of one kind of plant-food in the soil than others do. After a number of years the soil is so lacking in this particular compound that it is difficult to grow any kind of a crop on it.

When legumes are rotated with other crops the

supply of nitrogen is kept constant in the soil. Rotation also gives an opportunity to kill out weeds that are likely to persist if the same crop is grown year after year. It also helps to get rid of certain insect pests. Every farmer must settle for himself the crops that are to be rotated; but he should adopt a definite system of plant rotation and follow it in regular order year after year. A common rotation in the corn belt is oats, clover, corn.

4. **Fertilizers.** Fertilizers are of two kinds, natural and commercial. Of the first barnyard manure is the best. It not only increases the humus of the soil, but it is rich in the three elements that soil needs, nitrogen, phosphorus and potassium. Green manure is another natural fertilizer. This means the plowing under of green crops. All the legumes as clovers, cow-peas and alfalfa, when plowed into the soil are green manures. Rye and rape are also used for this purpose.

Commercial fertilizers, as the name implies, are materials that are bought and put in the soil. To supply phosphorus, bone-meal and rock phosphate are used. For nitrogen, Chile saltpetre (nitrate of soda), dried blood, and sulphate of ammonia are used. For potassium, different forms of potash are used.

If calcium is lacking in soil lime should be used. It

is also used to sweeten sour soil. When soils become sour, the bacteria cease to change the organic material into humus. Plants do not thrive well in sour soil. Any soil that has been used for a long period of years is likely to become sour and is improved by an application of lime.

Look up carefully what methods of rotation are practiced in your community; also what special means are taken to maintain the fertility of the soil.

CHAPTER VIII

THE WORK OF PLANTS

Materials. Potatoes, grains of corn, flour, oatmeal, corn-starch, seeds of sunflower, cotton, flax, squash or pumpkin, solution or tincture of iodine.

Plants use some of the water that they obtain from the soil in the manufacture of food and other products.

Experiments. What foods and products do plants manufacture? Scrape as fine as possible one or two potatoes. Place the scrapings in a tumbler of water, stir thoroughly two or three times, and allow to settle. Examine next day. What do you find in the bottom of the tumbler? Drain off all the water and potato pulp, leaving nothing but the starchy looking mass in the bottom. Boil some water over the alcohol lamp and pour a little of this into the tumbler, stirring until the mixture thickens. This resembles ordinary laundry starch.

There is a chemical test, however, that will prove beyond doubt that you have starch in the tumbler. Place a small quantity of the cooked starch on a plate or saucer, and then put two or three drops of iodine

on it. What is the effect of iodine on the substance? The blue color indicates the presence of starch. The darker the blue the more starch there is present. Sometimes it is almost black. Place a drop of iodine on a slice of raw potato. Does it show as much starch as that which is cooked? The reason the latter shows more starch is that the boiling water causes the walls of the starch granules to burst open and the iodine can act more readily upon the starch.

Pour a little boiling water over some flour and test it for starch. Make the same experiment with corn-meal, oatmeal and corn-starch.

Soak some grains of corn for forty-eight hours, or for an hour in hot water. At the pointed end of the grain find the tip cap. Remove this. The cap may be lacking on some grains, having been left on the cob. With a knife or pin remove the hull. You will see that the grain under the hull is covered with a thin, smooth material that with care may be scraped off with a knife. This is called horny gluten. Now dig out the germ or embryo. This is the light gray, oval shaped portion that fills up the groove in the soaked grain.

Split open the remaining part of the grain. How many kinds of material are left? Place by itself the white granular material found near the crown of the grain. Add to it the same kind of material found

near the tip. Put the hard, solid looking substance in another pile. You now have six different substances found in your grain of corn. Test each of these with iodine as you did your potato starch and flour. It is best to crush them as much as possible before putting on the hot water. What part shows the most starch? It is probable that the soft granular part will turn the darkest blue. This part is known as crown starch. The solid, hard part, if thoroughly boiled, will show some starch. This is called horny starch. What parts do not contain starch? This means, of course, that there must be some substances other than starch in the grain of corn.

Remove some fresh embryos from soaked grains and crush them on a sheet of white writing paper. Hold the paper between you and the light. What do you see? The grease spot indicates the presence of oil or fat. Test other seeds in this way for oil, such as sunflower, squash, pumpkin, flaxseed, etc.

Put a small pinch of each of the following on a sheet of paper; flour, corn-meal, any cereal breakfast food, buckwheat, and ground coffee. Place the sheet in a hot oven and keep it there a few minutes. What evidence is there that these things contain oil? Name some plants whose seeds contain so large a percentage of oil that it is extracted and used for commercial purposes.

Discussion. Besides starch and oil, plants contain other substances.

The embryo of the corn is composed largely of protein. Another substance in plants is sugar. A sweet potato tastes sweeter than a white potato because it contains more sugar. Name other plants that have sugar in them. From what plants is the sugar of commerce obtained? All starch found in plants is changed into sugar before it can be absorbed by plants or animals. Starch is insoluble in water, and all substances absorbed by living bodies must be soluble.

The corn hulls are composed chiefly of a substance called cellulose. Cellulose is found in all plants. It is the material that gives strength and firmness to the different parts. It is found in the cell-walls, in fibers of stems, roots, and leaves, as well as in fruits and seeds. It is harder and thicker in some parts of the plant, as in the stems, husks and roots, than in others. The fibers of cotton, hemp, and flax are made chiefly of cellulose. Soak some newspapers or writing paper in water till all the sizing is washed out. The pulp that remains is almost pure cellulose. Much of our paper is made from wood pulp; that is, from the cellulose of the woody stems of trees.

Where do the plants get all of these substances? They manufacture them. All plants that have green

leaves or green coloring matter in any part manufacture starch, sugar and other products.

You may think of plants, then, as factories, with machinery, power, and raw materials. The raw materials are found in the air, soil, and soil-water about the plant. They are found in the form of chemical compounds which the plants take in and use. You may not know what a compound is. Water is an excellent example. It is formed by the union of two elements, oxygen and hydrogen. Both of these are invisible gases which do not at all resemble water. An element is a substance that so far as chemists know cannot be separated into other substances. There are between seventy and eighty elements known. All other things in the world are compounds, formed by the union of two or more elements. Just to mix elements together will not make a compound. They must unite in definite proportions. In order to understand what we mean by this you must know that everything in the world is made up of very small particles called molecules. The molecules are so small that they cannot be seen by the most powerful microscope. Each molecule is made up of still smaller particles called atoms. Now, when a chemical union takes place a certain number of atoms of one element unite with a certain number of atoms of another element or elements and make a molecule

of a new substance which is a compound. In water two atoms of hydrogen unite with one atom of oxygen; hence we use the symbol H_2O to stand for water.

Chemical unions are taking place constantly in the world of nature. In plants, chemical combinations take place which result in the plant products you have found. Starch is a combination of oxygen, hydrogen and carbon. The symbols for these elements are O, H and C respectively. Proteid is a combination of carbon, hydrogen and oxygen, with nitrogen, sulphur, phosphorus, and often other elements.

The plant gets its oxygen and hydrogen from the water which it absorbs through its root-hairs. It gets carbon from the air, not as an element but the compound that you know, carbon dioxide. Its symbol is CO_2. This tells you that one molecule of carbon dioxide is made by the union of one atom of C and two of O.

The work of manufacturing starch takes place in the leaves or other green parts of plants.

Examine a leaf of any plant. Hold the leaf between you and the light. What do you see in it? How are the veins arranged in a bean leaf, maple, sunflower? These are net-veined leaves. How are the veins arranged in a corn leaf? In grass? These are parallel veins. What is the use of the veins? One apparent use is to hold the blade spread out to the light.

Place a twig with growing leaves in a tumbler of water colored with red ink. After twenty-four hours examine the petiole and the veins. The red ink in the veins tells you that they carry water to all parts of the leaf.

Procure a thick leaf, as live-for-ever, tulip, or hepat-

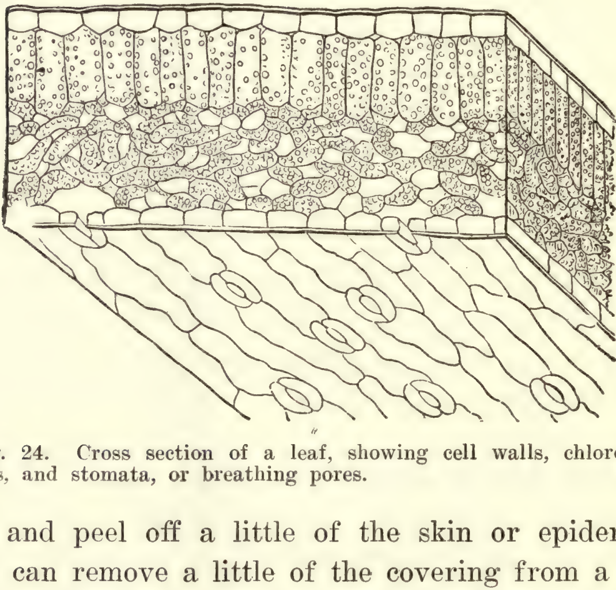


Fig. 24. Cross section of a leaf, showing cell walls, chlorophyll bodies, and stomata, or breathing pores.

ica, and peel off a little of the skin or epidermis. You can remove a little of the covering from a thin leaf, enough to see that the entire leaf is covered with a thin, almost transparent skin. What is under the skin? This green granular mass is largely made up of a substance called chlorophyll.

If you could see a cross-section of a leaf highly magnified you would find it built up of cells. Each

cell has a thin wall, contains green, roundish bodies called chlorophyll bodies, and a mass of colorless protoplasm. These form the machinery that manufacture plant-food. But just as any machinery must have power to make it run, so must the machinery of the leaf. What is the power?

Experiment.* Fill a box or dinner plate with soil and sow some oats or wheat seeds. After the grains have sprouted cover one-half the plants with a box or tin can. Give all the plants the same amount of water. After a week compare the plants grown under cover with those grown in the light. What do the former lack? What is your conclusion as to the ability of the plants to make chlorophyll without the aid of light?

Discussion. Recall the color of grass that has been covered with a board, or the color of potato sprouts in a cellar. Without light plants cannot make chlorophyll, and without chlorophyll no starch can be made. The light is the power that runs the machinery, but the chlorophyll is the connecting link between the power and the machine. In some way it succeeds in bringing them together so that they are able to carry on their work.

You remember that starch is made out of oxygen and hydrogen from water and carbon from air, and

*This experiment should be started a week before time for the lesson.

that proteids contain these three elements with the addition of nitrogen, sulphur, phosphorus, etc., which come from the soil.

The leaves take in carbon dioxide through their stomata, which are small openings in the epidermis. What must be done with this compound before the plant can use the carbon? It must be separated into its elements, oxygen and carbon. The protoplasm decomposes the carbon dioxide and uses the carbon. It throws the oxygen back into the air. Therefore, when a plant is actively engaged in manufacturing starch it is taking carbon dioxide from the air and giving out oxygen. Why cannot this process be carried on during the night?

What do the plants do with the starch, proteids, and oils that they make? The starch, by a process something like digestion in our bodies, is changed into sugar, and this and the other foods are conveyed in liquid form from the leaves to all parts of the plants, where they are used in the growth of these parts.

Do plants grow at night? Measure some of your corn or other plants at night and again in the morning and see how much they have grown. While plants cannot make food at night, they can use the food they have made during the day for growth during the night. Some of the food that is made is not used at

once but is stored away for future use in roots, stems and seeds.

Plants need something besides food in order to live and grow. They are like animals in this respect. They must have air to breathe as well as food to eat. They cannot live without oxygen any more than you can. They carry on respiration at all times just as you do. Not only the leaves but the stems and roots need oxygen. The oxygen is taken into the cells and unites with the carbon and other elements giving the plant its energy. Waste products, CO_2 and moisture are thrown out into the air.

You must not confuse the two great processes that plants perform. In making starch plants take CO_2 from the air and give out oxygen. In respiration they take oxygen from the air and give out CO_2. The fact is that much more CO_2 is used in the manufacture of food than oxygen in the process of respiration, so that actively working plants give out much more oxygen than they take in. These two processes go on at the same time during daylight just as digestion and breathing go on in your body without interfering with each other.

CHAPTER IX

FOOD AND HEALTH

The foods that plants make feed many of the animals of the world including man. Since this is true you will readily see why the human body is composed of precisely the same elements that plants use in their food.

Classes of food. We group foods according to the elements they contain as follows: (1) carbohydrates, which are starches and sugars. The term tells you that the elements composing them are carbon, hydrogen and oxygen. A chemical compound whose name ends in the syllable *ate* always has oxygen as one of its elements. (2) Proteids, which contain carbon, oxygen, hydrogen, nitrogen, sulphur, and phosphorus. (3) Fats, which are composed of carbon, oxygen, and hydrogen, but these elements are combined in different proportions from those in starch.

Carbohydrates. Make a list of all the sources of starch that you know. Do the same for sugar. You will find that you have a long list. All the cereals, as wheat, corn, oats, rice, etc., and the vegetables, as potatoes, sweet potatoes, and fruits, have starch or

sugar as a large part of their composition. The chief value of carbohydrates in your body is to produce heat and energy. From your study of oxidation you know that this process takes place in the cells of your body.

Proteids. All grains, especially their embryos, contain some proteid. Beans and peas have a larger percentage of proteid than other vegetables. All other vegetables and fruits have small amounts. Most of the proteid foods are obtained from animals. All lean meat is largely proteid. The white of egg, milk, cheese and fish are all proteid foods. Proteid is the tissue builder of the body. It alone contains nitrogen, the element which is necessary in the making of protoplasm. There can be no building of new cells or repairing of old ones without proteid. The muscles and other organs are constantly wearing out and must have this kind of food to replace them.

Fats. Make a list of the sources of fats or oils and the foods in which these are found. You probably have in your list fats of animals and butter fat from milk, as well as vegetable oils from cotton seed, olive seeds, corn, etc. Fats are heat making foods and like carbohydrates they produce energy. Fat which is not used at once is stored in the body for future use. During an illness people become thin and wasted because their bodies have had to use up all the surplus

store of fat. Now since each of the three great classes of foods, proteids, fats and carbohydrates, has its special use in the body, you can see that we must have some of each of these foods daily in order to keep the body in good condition. Some people eat too much proteid, others not enough. Too much proteid may cause diseases of the kidneys, because these are the organs that get rid of the waste from nitrogenous foods. Too much fat and carbohydrate may result in the storing up of so much fat that it is injurious to the body.

Cooking. Most foods must be properly cooked in order to be wholesome. Cooking produces chemical changes in many foods and gives them a better flavor. In most cases it makes foods easier to digest and helps to kill off dangerous bacteria that may be in them. The method of cooking has much to do with the wholesomeness of foods. Roasting or baking meat is much better than frying. Few vegetables, even potatoes, should be fried; instead they should be baked, creamed or scalloped. Fried foods are the cause of many cases of indigestion and poor health, because, in the process of frying, the food becomes coated with a hard layer of fat which must be dissolved before digestion can take place. Starchy foods should be cooked thoroughly so that the grains of starch will be wholly softened. Proteids should

as a rule be cooked slowly and should not be overdone.

Digestion. Foods to be of value in the body must be changed into liquid forms so that they may be taken into the blood and carried to all parts of the body. This process is called digestion. It begins in the mouth where the teeth break up solid particles into small bits. Besides this mechanical change in the mouth, the saliva acts chemically upon starch changing it to sugar. When the food reaches the stomach a fluid called gastric juice is poured upon it. This acts chemically upon the proteids changing them to another substance called peptones. The food then passes on into the small intestine where several other juices act upon it to finish the digestion. These are the pancreatic juice, which comes into the intestine from the pancreas, the bile, which comes from the liver, and some juices that pour out of the walls of the intestine. By the time these have acted upon the foods, the starches are all in the form

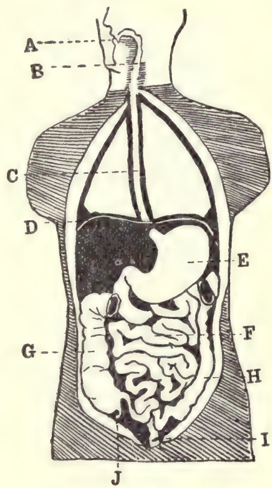


Fig. 25. The digestive tract: A, Mouth; B, Pharynx; C, Esophagus; D, Diaphragm; E, Stomach; F, Small intestine; G and H, Colon; I, Rectum; J, Appendix. Transverse colon is cut out.

of liquid sugar, the fats are broken up into tiny droplets, and the proteids have all been changed to peptones. The digested food is now in a condition to be absorbed into the blood.

The lining of the small intestine is thickly covered with tiny finger-like projections called villi, about as close together as the nap on felt or velvet. In each villus is a little tube called a lacteal which takes up the fat droplets. There are also tiny blood tubes in the villi which take up the sugars and peptones. The process by which these liquid foods enter the blood is precisely the same as that by which the soil-water enters the root-hairs of plants, and is called osmosis.

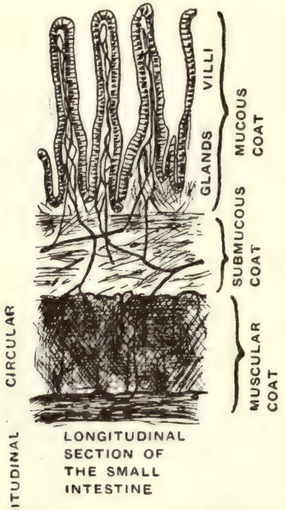


Fig. 26. A cross-section of the wall of the small intestine magnified.

The fats are carried into a large tube called the thoracic duct. This empties into a vein near the collar bone, and this in turn empties into a large vein which enters the right auricle of the heart. The sugar and peptones pass into the blood of a large vein which empties first into the liver. From

here the blood goes through other veins to the right auricle of the heart. Then it is sent to the lungs to get a supply of oxygen, after which it returns to the heart to be distributed throughout the body.

Hygiene of eating. If the food that you eat does for you all that it should, you must observe certain rules and regulations. First of all, you should chew your food thoroughly.

One reason for thorough chewing is that it gives an opportunity for a larger amount of saliva to mix with the food and help to change the starch to sugar. The other reason is that by breaking up the foods the gastric juice in the stomach has a better opportunity to act upon the proteids.

A second rule to observe is to eat regularly, that is, eat at meal time and not between meals, unless you are really hungry. If you have an early breakfast and become very hungry before the noon meal, form the habit of eating a small amount or drinking a glass of milk about the middle of the forenoon. Avoid eating candy, nuts, ice cream, etc., between meals. Such things are best eaten as desserts of the noon or evening meals.

Third, eat plenty of vegetables and fruits and not much meat. Meat once a day is enough for any healthy person.

Fourth, avoid stimulants of all kinds. Tea and

coffee are not good for children. Alcoholic drinks are generally injurious to health and rarely do any good even when used as medicine. Everyone knows how harmful they are. Patent medicines should also be avoided. They are the source of much trouble in the digestive organs. Medicine should be taken only under the advice of a physician.

The teeth. If you examine your mouth in the mirror you will find that you have in the back part of your jaw on each side, two or three broad, flat teeth. These are called molars and their sole purpose is to crush and grind up the solid food till it is reduced to a pulp. Most people do not get the last molars, known as the wisdom teeth, until they are from sixteen to twenty years of age. In front of the molars on each side are somewhat smaller teeth which also aid in grinding. These are called bicuspids. In front of the bicuspids are the sharp tearing teeth called canines, and in front of these the two cutting teeth called incisors.

Care of teeth. To keep the teeth in good condition is a prime requisite to good health. Teeth that are not kept clean serve as a lurking place for all sorts of disease bacteria. If particles of food are left in the mouth, around and between the teeth, they form an excellent place for bacteria to grow and multiply. Physicians believe they have good evidence that the

ill health of many people may be traced directly to teeth that are in bad condition.

The teeth should be brushed at least once every day, better twice. The mouth should be rinsed thoroughly with water after each meal. A dentist should be visited at least once a year, better twice, so that he may detect any evidence of decay in the teeth and attend to the matter at once. Thousands of young people through lack of care lose second teeth that could easily be saved for service and beauty during many years.

Care of foods. Foods should be so cared for that there may be little danger of spreading disease through them. Foods that are exposed to dust in stores or on the street should be thoroughly washed before eating, especially those that are eaten raw. Vessels in which foods are kept should be carefully washed and sterilized with boiling water, and occasionally left standing out in the hot sun.

People who cook food should use the greatest care to cleanse their hands and nails perfectly before they handle the food. Under no consideration should one who is waiting on a sick person go into the kitchen to cook without first washing his hands in a weak solution of cabolic acid or other disinfectant.

Food should be kept from spoiling by keeping out bacteria as much as possible; that is, by cleanliness,

and by keeping the foods cool so that bacteria will not grow and multiply in them.

All the people in a community who are thoughtful about health conditions should cooperate to see that stores and markets in which food is sold are kept absolutely clean and sanitary.

SPRING STUDIES

CHAPTER X

GARDEN STUDIES AND HOME PROJECTS

Getting ready for the garden. Gardening should mean something more to you than merely planting, cultivating and harvesting crops. Through it you will be able to discover many scientific truths and underlying principles concerning the life and habits of plants, kinds of soil, principles of drainage and the vitality of seeds. This means that special studies and experiments must go along with your gardening. Then, too, you must conduct your work according to sound business principles if you wish to get real value out of it.

One of the first things to do is to write to seed firms for catalogues and send for your seeds. There are a number of associations and seed houses that make special prices to school children.*

Look over the garden projects suggested in this chapter before you decide definitely what to plant.

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*Two of these are: The Children's Flower Mission, Cleveland, Ohio; The School Garden Association, Boston, Mass.

You should be influenced in your decision by the disposal you expect to make of your garden products. If you are planning to use your vegetables upon the home table, you should consult with the family to find out what they prefer. If you expect to market your produce, you should find out from grocerymen or truck gardeners what vegetables are likely to be in greatest demand.

It is worth while also, if you have a good sized plot, to give a small space to new or unusual vegetables. There are a number of palatable and nutritious vegetables that many people do not grow or use because they know nothing about them. You may succeed in introducing some of these into your home and neighborhood. If you have a small plot on the school grounds it may be used as an experimental garden in which new varieties of vegetables may be grown and tested. The small school plot may also be used to demonstrate some of the principles of gardening, as well as to raise material for special study.

Tools. If you are starting a garden for the first time, you will have to purchase tools with which to work, unless your parents have all that are necessary. If they garden on a large scale, they probably use some implements such as plows, harrows and cultivators drawn by horses. If you have a small

garden of your own, you will need the following hand tools:

1. For preparing the seed-bed: a spade, spading fork, rake.

2. For planting: a line, or measuring stick, hoe.

3. For cultivating: hoe, hand weeder, wheel hoe.

4. For raising plants indoors: shallow boxes, called flats.

5. For transplanting: a trowel, dibber, watering can.

Making a hotbed. A hotbed is an inexpensive and convenient place in which to raise plants that must be started very early in the season and transplanted afterwards.

The parts of a hotbed are: 1. The pit in which material is placed to furnish artificial heat. 2. The frame. 3. The sash.

The pit should be of such size that the sash will just cover it; an ordinary hotbed sash is six feet long and three feet wide. A small hotbed then, may be made 3x6 ft., 6x6 ft., 3x12 ft., according to the number of sashes. If you have an old window sash about the place, the pit may be made to fit this sash.

Dig the pit about two feet deep in a well drained spot. Place posts in the corners and nail planks to these. This makes the frame. The posts should extend twelve inches above the ground on the north

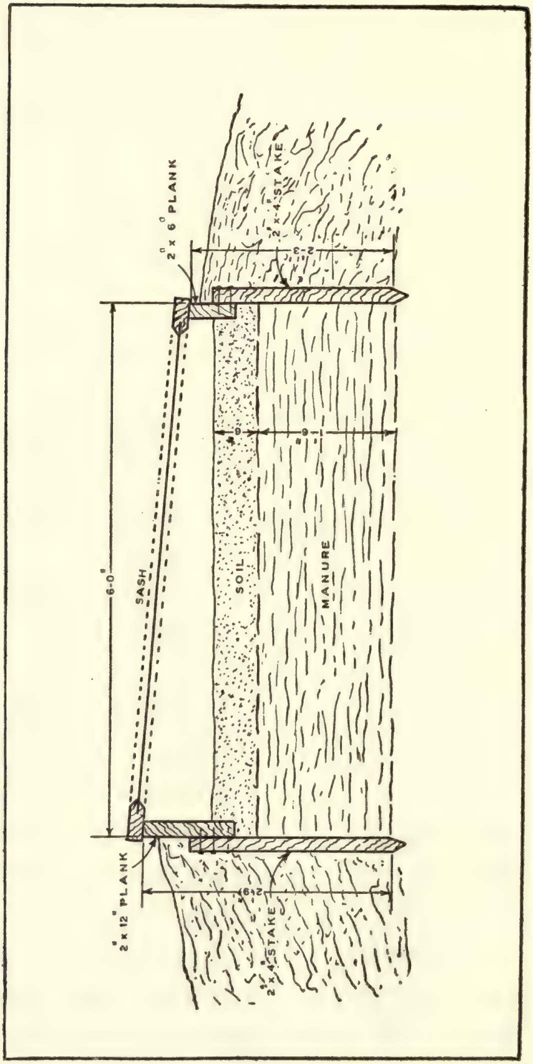

Fig. 27. A hotbed.

side and eight inches on the south, thus making your bed slope toward the south.

When the pit with the frame is ready, procure some fermenting stable manure, which is from one-third to one-half straw or litter used for bedding. Several days before making the hotbed the manure should be placed in a pile four or five feet high so that fermentation will begin. It should be turned over with a fork so that it will ferment evenly in all parts. Place a layer of this in the bottom of the pit and tramp or pound it down. Continue putting in layers and tramping them until the manure is from fourteen to fifteen inches deep. On top of this place a layer of good soil about four inches in depth.

If the bed is more than three feet long, place supports for the sashes every three feet. If it is very cold weather, a double sash should be used. A layer of manure piled around the frame on the outside will be of service in conserving the heat.

Planting. The hotbed is now ready for use unless the temperature is too high. Heat is produced by chemical changes that are taking place in the decaying manure. Place a thermometer in the soil and wait for the right temperature. A few plants like egg plants, peppers, or tomatoes may be planted when the temperature is between 85° and 90° F. For most seeds a temperature between 70° and 80° F. is safest.

Plant your seeds in rows, extending north and south. You may put the rows quite close together, from four to six inches. The soil should be slightly moist when you plant the seeds. Firm the soil over the seeds just as you would if you were planting them out-of-doors in the garden.

Care of the hotbed. Three conditions are essential in having your plants grow successfully in a hotbed:

1. The temperature must be kept as even as possible.

2. The soil must be kept moist.

3. The plants must receive a supply of fresh air.

Watering should be done in the morning rather than in the evening. On bright warm days the sash should be lifted a little, from one to three inches, in order to admit fresh air and allow impure air to escape. It may be left open two or three hours in the middle of the day. If the weather turns suddenly cold, an extra covering of boards, pieces of old carpets or canvas should be thrown over the hotbed at night.

A hotbed in connection with a school garden may furnish enough plants for all the children to set out in their home or individual gardens.

Hotbeds are sometimes used to raise certain plants as lettuce, radishes and spinach for table use during cold weather. Sometimes steam or hot water pipes

are used instead of manure to produce the needed heat.

Cold frames. A cold frame is another device for raising plants that are to be transplanted. It is similar to the hotbed except that it does not have the manure to produce artificial heat. It consists, then, of the frame and the sash. A frame may be made so that it may be moved from one place to another.

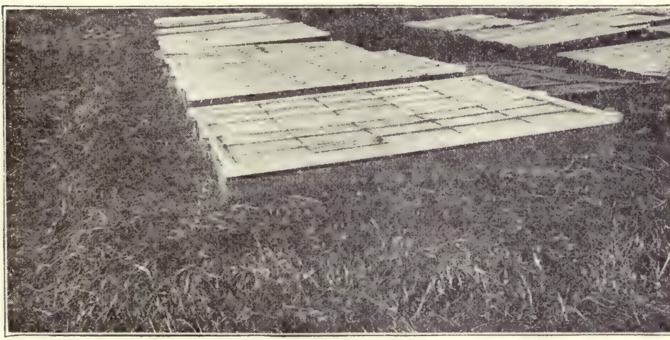

Fig. 28. A cold frame.

The frame should be twelve inches high on one side and eight inches on the other, just as the frame of the hotbed. It should also be the proper length and width to fit the sashes. It may be placed in a well drained spot in the garden. The soil should be dug and thoroughly pulverized before the frame is put into place. A layer of manure around the outside will help to keep the temperature even.

A cold frame may be used to start certain plants that later may be transplanted to the garden. Cabbage, cauliflower, tomato plants, brussels sprouts, and kohl-rabi may be grown successfully in a cold frame, planting them the latter part of March or the first of April. Some flowering plants from which you wish to get early results as cosmos, gaillardia, sweet scabious and salvia, may be started in the cold frame and then transplanted to the garden.

The care of plants in the cold frame is similar to that employed in the use of the hotbed.

Cold frames are frequently used to harden plants that have been grown in hotbeds before setting them out in the garden.

Do you know why the temperature of the cold frame is warmer than the outside air? The answer involves a principle of physics. The heat rays of the sun pass through the transparent glass and heat the soil in the cold frame. The heat that radiates from the soil cannot pass out through the glass, so you see it must accumulate inside the frame.

Preparing the seed-bed. To insure a successful garden you must see that the soil is in good condition before you plant your seeds or set out your plants.

Plow or spade it to a depth of from 10 to 12 inches. A spading fork will give better results than a spade. Then pulverize it with a harrow or rake till it is fine

and mellow. If it is a clay soil be careful not to work it when it is very wet. If when you take up a handful and squeeze it the particles stick together and will not fall apart when you drop the lump, it is too wet. If the particles fall apart the soil is in good condition so far as moisture is concerned.

In order to have a successful garden it must be well drained, must be rich in organic matter or humus, and contain in available form all the soil elements that plants need for their growth. In order to keep the soil in excellent condition, with a constant supply of moisture, you must cultivate your garden frequently. Never allow a crust to form and remain. This means cultivating after every rain.

BOYS AND GIRLS CLUBS

While any of the projects suggested in this and other chapters may be undertaken individually in your home, it will add both interest and profit to the work if a number of boys and girls of the community meet and organize a club. Here various kinds of work may be discussed and you can decide what particular projects you wish to undertake as a club. The value of the club is that it affords an opportunity to learn much from each other about the work. You will be more interested in the work itself when you know what others are accomplishing. Then, too, it affords an excellent opportunity to receive some training in conducting public meetings, in parliamentary practice, and in speaking before the public.

Many state universities have in cooperation with the U. S. Department of Agriculture and the Bureau of Education a club leader who gives his entire time to the work of helping boys and girls to form clubs and to carry on projects in connection with them. If

you wish to organize a club the first thing you should do is to apply to the club leader of your state for information. He will send you bulletins and other material explaining exactly how to proceed.

PROJECT ONE

TOMATOES

Material. Seeds and seed catalogues; flats or boxes.

If you are planning to raise tomatoes, you should decide first of all whether you want to try more than one variety. Looking in your seed catalogue you find some listed as early varieties, other as late. Usually the early tomatoes are smaller than the main crop tomatoes. It is worth while to grow a few of these for early market or home use; for canning the larger varieties are better.

Planting. If you live in a warm climate plant your seeds out-of-doors; if in a cool climate, you must start them in-doors. Can you explain why? It is because the tomato is not hardy enough to plant out-of-doors early in the spring in a cold climate. If you wait until the ground is warm enough for the seeds, the season will be too short for the fruit to ripen.

Place some good rich soil in a box. Use a flat or a shallow box about two and one-half or three inches deep. Scatter the seed broadcast over the soil or sow in drills two inches apart. Cover with about one-half inch of soil and firm the soil well.

If you have a hotbed, place the flat in this; keep well watered and ventilated. If you have no hotbed, the plants will do fairly well in a sunny window in the school room, or in the kitchen. Care should be taken not to allow them to chill on cold nights.

If the plants are not too crowded, they may be left in the flats until time to transplant. You will get better results, however, if when the plants are between two and three inches high you transplant them to small flower pots, old berry boxes, tin cans or into other flats. If you use the cans, be sure to punch holes in the bottom for drainage. Do not keep the plants too warm, but allow them to grow rather slowly in order to form a thick stocky stem.

Transplanting. When all danger of frost is past, transplant to the garden. The small early varieties may be placed two and one-half or three feet apart; the large ones from three to four feet.

Care of plants. As you know, the tomato plant has a weak stem which if left to itself will spread over the ground. To get best results you should make a support of some sort. Soft twine or strips of cloth should be used to tie the plants to the support.

It is not well to allow all the buds that appear to develop. If you look closely at your plants when they are four or five inches high you find new buds appearing in the axils of the leaves. Most of these

should be pinched out. This compels the plant to grow tall. When your plant has a number of fruit clusters on it, you may prevent its growing taller by pinching out the top bud. You should cultivate frequently enough to keep a soil mulch.

Experiments. (a) Test two or three varieties to determine which gives best results. (b) Train several plants on supports. Leave the same number untrained. Keep a record of results.

Harvesting and canning. If you are marketing your crop, be careful not to bruise the fruit. Put together the tomatoes that are similar in size, shape and color. You will get a better price for choice fruit if you grade it carefully.

Seventh and eighth grade girls can successfully can tomatoes. Select firm, thoroughly ripe fruit. The skins are removed by placing the tomatoes for a few seconds in water heated to the boiling point. Remove, dip immediately into cold water, and the skins will slip off easily.

There are two methods of canning that you may use. The old-fashioned plan is to cook the tomatoes, then place them in cans and seal. First the cans, tops and rubbers should be sterilized by immersing in boiling water.

The newer and better plan is the cold pack or hot water-bath method, using the closed boiler or the

home canning outfits. Both of these methods with much useful information are described and explained in Farmers' Bulletin No. 521, "Canning Tomatoes at Home and in Club Work." This may be obtained free by sending to the U. S. Department of Agriculture, Washington, D. C.

It will be quite worth while for a school to have in connection with the Domestic Science department a canning demonstration with a wash boiler or deep kettle and a canning outfit.

You may use your tomatoes also for pickles, chow-chow, piccalilli and sweet preserves. You will find recipes for these in the bulletin named above.

Record of Tomato Project.

1. Name of variety.
   a. Date of planting.
   b. Date of transplanting.
   c. Date when ready for use.
2. Expenditures.
   a. Cost of seeds.
   b. Rental value of plot—size of plot.
   c. Labor—Estimate hours of work.
   d. Cost of fertilizer.
   e. Total expenditure.
3. Receipts.
   a. Yield in pounds or bushels.
   b. Amount sold—value.
   c. Amount used or canned—value.
   d. Total receipts.
   e. Net profits.
4. Note any points that will be of value for future reference.

PROJECT TWO

ROOT CROPS

Material. Roots of beets, turnips, parsnip, carrot, and salsify; seeds of each.

Root crops is a name given by market gardeners to plants whose roots are used for food. Make a list of all the root crops that you know. Choose any one of them for observation and study. The study may be made late in the fall or any time during the winter or early spring.

Seed-bed and seeds. Work the soil thoroughly so that it will be loose and deep. It should also be well drained.

The seeds of most root crops do not retain their vitality more than two years. It is safer to use one-year-old seeds.

If you are not sure that the seeds are fresh, test them to see if they will germinate. Place a few in moist sand or soil. Keep moist but not too warm and watch to see whether they will germinate and grow. The seeds are slow to germinate, taking from ten days to three weeks, so do not be discouraged when the plants do not appear within a few days. You should make the test during the latter part of winter or early spring.

Planting. Time: All the root crops are cool weather

plants and may be planted as early as the ground can be worked in the spring. Beets, carrots, and turnips may be planted at intervals during the summer for a succession of crops.

Distance apart of rows: Beets, carrots, parsnips, salsify, turnips, 12 inches.

Depth: All the above except turnips, 1 inch. Turnips ½ inch.

It is very essential to firm the soil well. If the seeds germinate they must be kept moist. Firming the soil brings it in close contact with the seeds, so that the moisture is kept constant by capillary action of the soil.

Some gardeners plant small, quick germinating seeds, as radishes or lettuce, in the rows with parsnips and carrots. These help to break the crust for the slower plants and at the same time mark the rows so that the soil can be cultivated without the possibility of injuring the young seedlings that may be just ready to break through.

Thinning. It is a good plan, in order to secure a good stand, to plant the seeds rather close, about an inch apart. If all grow, thin to a distance of from 3 to 4 inches.

Harvesting. Beets will be ready to use in from 8 to 10 weeks after planting. They are much better when young than if allowed to reach their full growth.

They may be canned successfully by the closed boiler or steam method.

Carrots are ready for use in from 12 to 15 weeks. They too are better young. They may also be canned. Both beets and carrots bring a better price at this time than later. Turnips are ready in from 8 to 12 weeks. Parsnips and salsify may be left in the ground and used during the winter. While some people think that frost improves them, they are all right to use in the early fall.

Any of the root crops may be kept fresh and crisp for use all winter by placing them in boxes of moist soil, sand or leaves, and keeping them in a cold cellar. A temperature just above freezing is best. They may also be kept in pits out-of-doors. To preserve them in this way they should be placed in a conical pile, covered with six or eight inches of straw, then with a layer of earth. In very cold regions a layer of manure may be put on top of the soil.

Experiment. (a) If you have an experimental plot, set out some roots of beets, carrots, etc., and raise some seeds of your own.

(b) Try different varieties of any of the root crops suggested to determine which give best results in your garden.

Keep a record of your crop similar to the one suggested for tomatoes.

PROJECT THREE

POTATOES

Material. A number of potatoes, a small bottle of tincture of iodine, some red ink.

Study. Examine a potato. What do you find scattered over the surface? Where are the eyes most numerous? Where are the smallest ones; the largest? What are the eyes? Do any of them show signs of growth? What else do you find on the potato?

The eyes are buds, and the end of the potato on which the eyes are so numerous is called the bud or seed end. Opposite this is the stem end.

What is the potato? To answer this, hold a potato with the bud end upward. Now suppose you could stretch it out many times its length and have the thickness reduced accordingly. What part of a plant would it resemble?

Cut a potato in two through one of the eyes. How many different structures has it?

Experiment. What is the potato made of?

1. Weigh a potato after first removing the peeling. Put it in a warm place. What happens? After a few days weight it again. How much has it lost? What causes the loss?

2. Scrape the white portion from two or three potatoes. Put the scrapings into a glass of water.

Stir thoroughly. Allow the glass to stand for twenty-four hours. What do you find in the bottom? Carefully pour off the scraps and water leaving nothing but the white layer in the bottom. Pour a small amount of boiling water over this. What happens? Put a few drops of iodine on the starch and note effect.

Experiment. Of what use is the starch to the potato? Fill a box or large flower pot nearly full of soil. Plant two small sized potatoes. Cover about two and a half inches deep. Keep watered. When the plants are about three inches high dig up one and examine the potato noting any changes that have taken place. Leave the other for a number of weeks, then examine it. The same experiment may be tried to better advantage out-of-doors in the garden.

Experiment. Cut a slice from the stem end of a potato tuber. Set the cut end of the tuber in a dish with about a quarter of an inch of red ink in the bottom. Allow it to stand several hours. Now make a number of thin slices. What has taken place?

Discussion. The fact that the potato has buds tells you that it is a stem. Since it grows in the ground it is an underground stem. There are several different kinds of underground stems. This kind is called a tuber. In propagating potatoes then we use tubers instead of seeds.

The tuber is made up chiefly of water and starch. The blue color that appeared when you used the iodine indicated the presence of starch. The potato also contains a few minerals. Its structure is like that of any stem. The outside layer we call the peeling. The dark line is the woody tissue. The part between the wood and peeling is the cortex. The dark central part, with the rays extending from it, is the pith. The white part is called the medulla. Your experiment shows that the woody tissue carries water and other food materials to the tuber.

Planting. Time: Early potatoes may be planted as soon as the ground is dry enough to cultivate in the spring. Late varieties may be planted in May or June. The northern states that raise quantities of potatoes usually plant them about the middle of May.

The seed-bed: Potatoes need a deep, rich, mellow seed-bed. To insure this the soil should be plowed deeply and then disked or harrowed a number of times. A soil that has had clover or alfalfa growing on it the year before is excellent for potatoes.

Cutting the tubers: Many experiments have been made at agricultural stations to determine the most economical way to cut the tubers for planting. A chunky, compact piece with at least two eyes usually gives best results.

Space between rows: In the garden where hand cultivation is practiced the rows may be 2½ feet apart. When the horse cultivator is to be used they should be 3 feet apart.

Space between hills: 12 to 15 inches. Plant one piece in each hill.

Depth: In heavy, compact soil 3 inches. In loose, mellow soil 4 to 5 inches.

Cultivation and care. Work the soil frequently; harrow the ground at least once before the plants are up. All through the growing season cultivate often enough to keep the soil fine and loose. Care should be taken not to cultivate too deeply lest the roots be injured.

Enemies. If you find traces of the fungous disease called scab on your seed potatoes you can prevent its attacking your new potatoes by treating the seed with a solution of formaldehyde. Use one ounce to two gallons of water. Leave the potatoes in the solution from one and a half to two hours.

The Colorado potato beetle is likely to be your worst foe. For treatment, spray with arsenate of lead or Paris green.

For potato blight spray with Bordeaux mixture or lime-sulphur mixture. The latter will also kill aphids or plant lice.

Harvesting, marketing and storing. Early pota-

toes may be dug for market when they are large enough to use before they are fully matured. If you are planning to sell your crop you may get a better price for it at this time than if you wait until later.

You will probably harvest your main crop when the potatoes are mature. This means when the vines are dead. If you store them for future use or plan to sell them later you should keep them in a cool, dark place at a temperature from 33° to 35° F. They may be stored in a cool cellar or in an outdoor pit.

Selecting seed potatoes. When digging your potatoes watch for hills that give the best yield; that is, the greatest number of large, well formed potatoes. Save these for seed next year. If you do not get enough choice ones to plant your entire plot, use these to plant a small plot and from this again choose the best hills. In the course of three or four years, by this simple plan of selection you may produce a seed potato that will be worth many times the price of ordinary potatoes.

Keep a record of your project similar to that suggested for tomatoes.

Experiments. There are a number of interesting experiments that you may make either at home or in the school garden.

1. Does careful selection of seed potatoes pay? Plant two plots of equal size, one with tubers care-

fully selected as suggested above, the other with tubers taken at haphazard from the bin. Give both the same cultivation. Compare weights when the crops are harvested.

2. Is it worth while to treat potatoes for scab? Plant two plots of equal size with the same kind of potatoes. Treat the tubers of one with formalin; plant the other with untreated potatoes. Compare as to yield and quality of potatoes.

3. What is the effect of frequent cultivation? Plant two plots of equal size with the same kind of potatoes. Cultivate one twice as frequently as the other. Compare yields. Keep a record of the extra time and labor expended so you may take that into consideration when you check up results.

4. Test two or three varieties of potatoes as to yield and quality. Plant plots of equal size and give similar culture. Some of the common early varieties are Early Ohios, Early Rose, Irish Cobbler and Early Puritan. The leading late varieties are Rural New Yorker, Seneca Beauty, Burbank and Green Mountain.

PROJECT FOUR

ONIONS

Material. Some large onions, several onion sets, seeds, and if possible a stem with top sets or bulblets.

Study. An onion is a bulb. Examine one care-

fully. What do you find at the lower end? At the upper end? Describe the covering. Cut one bulb crosswise and another lengthwise. Of what is the bulb composed? Where are the thickest layers? What is the color of the central portions? Look closely at the place where the layers are fastened. What is their relation to the hard flat plate that you found on the outside of the bulb? How is the central shoot related to this? What is this plate?

Experiment. What is the value to the onion of the thick, juicy layers?

Place a medium sized onion in the mouth of a large bottle full of water. The lower part of the bulb should rest in the water. Watch its growth for a number of weeks. Describe the roots and the leaves. Explain the change that takes place in the bulb.

Compare sets with large onions, noting differences and resemblances. How are the sets obtained? If you have some top onions or bulblets, compare those with the sets.

Examine the seeds. Note size, color and shape. How can you obtain onion flowers and seeds?

Discussion. The onion bulb is really composed of thick, juicy, modified leaves that contain a large amount of food. The flat plate-like portion to which they are fastened is the true stem of the bulb. You find from your experiment that the bulb sends out

the fibrous roots below and the green shoot above. If you examine the latter after a number of weeks, you find that most of the food in it has been used up and it has become very soft and flabby.

Sets and seeds. Sets are small bulbs that have been grown from seeds the year before. In some places the seeds are planted late in the season and in the fall the small bulbs are taken up and stored over winter. Most growers of sets, however, plant the seeds very thick early in the spring. The plants are so crowded that the bulbs cannot grow large. When the tops begin to die the small bulbs are taken up, dried and stored. Top sets or bulblets are produced by certain kinds of onions. They may be used to produce new onions just as the true sets are used.

Onions are biennials, so if you wish to raise seeds you must set out the large bulbs which send up a flowering stem. Sometimes the large sets will do the same thing. If they send up seed stalks they become tough and strong and are worthless. Sets from ½ to ¾ of an inch in diameter are the best size to use if you wish to raise ripe onions. The larger sets may be used for green or bunch onions.

Planting. There are several different methods which you may use to raise an onion crop. If you wish an early crop, use sets. You may also use bulb-lets or you may procure the potato onion or multi-

plier. This produces numerous bulbs growing around the bulb you set out. For an early crop you may set out multiplier onions in the fall. In a cold climate cover them lightly with leaves or straw. They will be ready for use very early in the spring. For the general crop plant seeds. Onions are hardy, cool weather plants, and it is quite essential to plant them very early so they may get a good start before hot weather.

Distance between rows, 12 to 16 inches.

Distance between sets in the row, 3 inches.

Sow seeds thick and later thin to same distances as sets.

Depth of seeds, ½ to 1 inch.

Depth of sets, place so the shoot will just come above the surface of the soil.

Firm the soil well over both sets and seeds.

Care of plants. Keep well weeded and cultivated. The hand and the hand weeder are the best tools to use at first with the seedling onions. After they are three or four inches high the wheel hoe or cultivator may be used.

Harvesting, marketing and storing. Onions raised from sets will be ready for use in from four to six weeks. Seed onions will be ready in from ten to twenty-five weeks.

If you live near a market where green or "bunch

onions" are in demand, it may pay you to market some of your onions just as soon as they are large enough to eat. Clean them carefully, trim off the fibrous roots and tie them in bunches of ten or twelve.

If you wish to wait until the onions are ripe, keep watch of the tops. As soon as they have fallen over and turned yellow you may be sure that your onions are in good condition to harvest. Pull them and twist off the tops. Some gardeners leave them lying in the rows in the garden to cure, but the method now employed by the best market gardeners is to place them in a dry, well ventilated place in the shade rather than in the sun. A shed or corn crib will serve the purpose. Spread them out so that the air may circulate well among them. Do not allow them to freeze. When cold weather approaches either sell them or put them in a place where the temperature remains above the freezing point.

Keep a record of your project similar to the one suggested for tomatoes.

Onions require considerable care and labor, but if you succeed in raising a good crop you will find them very profitable.

Experiments. a. Plant equal areas with sets and seeds. Keep separate records to determine which is more profitable.

b. Plant equal areas of different varieties of onions,

red, white, or yellow. Keep careful records to determine which gives best results.

PROJECT FIVE

CUCUMBERS AND OTHER CUCURBITS

Material. Seeds of squash, pumpkin, and cucumbers; small flats or boxes, soil or sand; seed catalogues.

If you are planning to raise cucumbers or any of their relatives, consult your seed catalog to decide what varieties you wish to grow. Some cucumbers are better adapted for slicing than others, while some are especially good for pickling. Some varieties of squashes and pumpkins are ready for use in the summer; other are not ripe until fall.

Seeds and seedlings. Soak some seeds twenty-four hours; squash or pumpkin seeds are best for this study because of their large size. Examine a seed and determine the point where it was attached to the inside of the fruit. Remove the covering and describe what you find on the inside. Consult Fig. 28 to get the names.

Experiment. What part of the plant will each part of the seed produce? To answer this question plant three or four seeds each of squash, pumpkin and cucumber in a box of sand or other light soil. Keep in a warm temperature and water frequently enough

to keep the soil moist. Record the date of planting. When the plants are up solve the following problems:

How long does it take each to appear above the ground? What part of the plant appears first? Do the seed coats come up? What changes take place in the cotyledons? Dig up one of the plants to determine what part of the seed produces the root. How do the first pair of leaves, the cotyledons, differ from the other leaves of the plant? (You may have to wait some weeks to answer this question.) What finally becomes of the cotyledons? Compare the seedlings with each other for likenesses and differences.

Discussion. No doubt you can see a strong family resemblance among the seeds and seedlings. The entire family are natives of warm regions.

The cotyledons which produce the first leaves have some food stored in them which starts the growth of the seedling. Then they begin the work of manufacturing food for the plant and continue to do this till other leaves are produced, when they wither and drop off.

Planting. Time: Cucumbers and their kin are warm weather plants so must not be planted until all danger of frost is past and the soil is warm. The soil should be well pulverized and very rich. It is sometimes a good plan to spade a fertilizer into it two or three weeks before planting time.

There are two methods of planting: 1. The mound hill, which is raised six to nine inches above the level of the garden. 2. The hill on a level with the garden soil. Whichever plan you use put ten to twelve seeds into each hill. This provides for the destruction of some of the plants by insects and yet probably leaves enough to insure a crop.

Distance apart of hills:	Depth:
Cucumbers, 4 to 5 feet	1 to 1½ inches
Muskmelons, 5 to 6 feet	1 to 1½ inches
Watermelons, 8 to 12 feet	1½ inches
Squashes and pumpkins, 8 to 12 feet	2 inches

Cucumbers may be started indoors six or eight weeks before they could be planted outside. Plant three or four seeds in good soil in an old berry box. Or cut a piece of grass sod about three inches thick and from four to five inches square, turn it upside down and plant the seeds in the fine soil. Keep in a hotbed or green house until danger of frost is past.

Care of plants. If all the seeds in the outdoor plantings germinate, allow the seedlings to grow for a while; then if none are destroyed by insects, pull the weakest plants leaving three or four of the strongest ones. Cultivate frequently till the plants have developed thrifty vines. To know how to treat insect and fungous enemies of your cucurbits see page 222.

Harvesting. If you are to use your cucumbers on

the home table, gather them when the right size to slice and keep in a cool place. Placing them in a refrigerator a couple of hours before peeling will improve their crispness. It is a mistake to allow them to stand several hours in salt water. This results in toughness. Cucumbers to slice are usually in demand on the market. Gather them every day or two, and use the same care to keep them fresh as you would for your own table.

If you are raising cucumbers for pickles, gather them at least every two days. Grade them, placing all of about the same size together. These may be pickled at home, or if you live near a pickle factory you will probably find a good market for them.

Record. Keep a record similar to the one suggested for tomatoes. Estimate their value by the dozen instead of by the pound.

Experiment. 1. Try two or three varieties keeping separate accounts to see which is most profitable.

2. Plant an equal number of mound and level hills and determine which gives the better results.

PROJECT SIX

BEANS AND PEAS

Material. Two or three different kinds of beans; box of soil or sand; seed catalogues.

Study. Soak some beans of any variety over night. Compare a soaked specimen with a dry one and note changes that have taken place. How many distinct parts do you find in the bean?

What will each part produce when the bean germinates and grows? To answer this question plant a number of seeds in a small box containing soil. Put in a warm place, the temperature of the room is all right, and keep moist. Watch for the appearance of the plants. How do they break through the soil? Dig up one seed just as soon as the cotyledons are out of the ground. Describe the root as to color, length and beginnings of branches. What part of the seed produced the root?

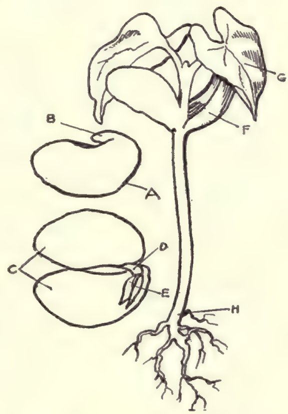

Fig. 29. Bean seed and seedling. A, One cotyledon; B, Hypocotyl and radicle; C, The cotyledons spread open; D, A small part of hypocotyl; E, Plumule; F, Cotyledons on growing seedling; G, Plumule developed into first pair of leaves; H, Root developed from the tip of the hypocotyl, the radicle.

Keep the plants till they are two or three inches high and note all the changes that take place. What finally becomes of the cotyledons? What value are they to the plant? What produces the first true leaves? When do the next leaves appear? Dig up another plant to discover any additional facts

concerning the roots. Look in your seed catalogues for the classes of beans that are listed. Determine how each kind is supposed to be used.

Discussion. You found your bean seed made up of three distinct parts besides the cover or seed coat. The thick cotyledons contain food for the growth of the little plant. You noticed that they changed in form and color; that is, they really grew a little themselves, but after most of the food in them was used they dropped off. They are sometimes called seed-leaves. The lower end of the hypocotyl produced the root; the upper part produced part of the stem.

How long beans have been used as food no one knows, but you will be interested to learn that most of the species of beans that we grow are natives of America.

Seed men usually classify their beans into string or pod beans, shell beans, and dry beans.

Of the string beans the entire fruit or pod with the seeds is eaten. Shell beans are removed from the pod and eaten while immature. Dry beans are ripened seeds that may be kept for months or even years.

Decide first what kind of beans you wish to grow. If you wish them for market or table use early in the summer, choose string varieties; if for market or use in the late summer or fall, choose some variety of shell bean. Nothing gives quite as good results at

this time as lima beans. Some of the shell beans may be allowed to mature and may then be used as dry beans. The navy beans are the best and most productive of the dry bean group.

Planting. Wait until all danger of frost is past and the soil is warm.

Space between rows:	Space between plants:	Depth:
Bush beans, either string or dry, 2 feet.	3 to 4 inches.	1 to 2 inches according to size.
Pole beans, 2½ to 3 feet.	4 to 6 inches.	2 inches.

If you wish a succession of string beans, plant some every two or three weeks. You may plan to use the space in which you have grown early crops of lettuce or radishes for your late beans.

Harvesting, marketing and canning. String beans are ready for use when the pod snaps easily. They are sold by the pound or quart measure. Good yielding varieties bring a good profit. The pole limas yield better than bush varieties. They sell exceedingly well when picked and shelled green. If you have more than you can market in this way, let them mature and sell them as dry beans.

All kinds of string and shell beans may be canned by the cold pack or hot water bath method. When the beans are cleaned and ready, dip into boiling

water, allowing them to remain three minutes. Remove and put into cold water. Pack into jars, add one level teaspoonful of salt to a quart and enough hot water to fill the jar. Put on the rubber and partially fasten the cover. Place the jars on the false bottom of the boiler and pour in cold water till it stands two inches above the jars. Allow them to boil one and one-half hours. Remove from the boiler, tighten the cover, and invert to cool.

Keep a record of your bean project.

Experiment. Test two or three different varieties of string beans to determine which gives best results.

Canning. Besides the vegetables discussed in these projects, many others that you grow may be preserved for future use by canning. The purpose of boiling before canning is to sterilize the vegetables so perfectly that no bacteria will be left to grow and multiply and thus cause souring and decay. Some vegetables, notably tomatoes, which contain considerable acid, are very easily kept in cans. The reason for this is that bacteria do not thrive well in an acid medium. Most fruits contain some acid and are more easily preserved by canning than vegetables. In order to kill all the bacteria in vegetables which do not have much acid, they must be subjected to heat for a long period. In the home the most common method of canning is called the hot water bath.

For this a large kettle or boiler may be used, a false bottom may be made out of wood, two pieces of two by fours with slats nailed across them. A wire rack which may be purchased for ten or fifteen cents is more satisfactory. Wire racks for individual jars may be bought for ten cents apiece. The steps in canning are as follows:

1. Can vegetables as soon as possible after taking them from the garden.

2. Have vegetables and jars perfectly clean.

3. Blanch the vegetables. This means plunging into boiling water for a definite period. A wire basket may be used, or they may be tied up in a square of cheese cloth. This preserves the color, hardens the tissues, and kills any baceteria that may be on the outside.

4. Plunge into cold water leaving but a moment.

5. Pack into jars. Put a teaspoonful of salt into each quart, then fill to the top with hot water.

6. Put on the rubber and the lid. Do not screw the lid tight.

7. Put the jar into the heater in cold or slightly warm water. Add water till the tops of the jars are covered about two inches.

8. Boil the necessary number of minutes.

9. Remove from the water, tighten the covers and invert to cool.

The following is a time-table taken from the supplement to Farmers' Bulletin, No. 521, Washington, D. C.:

TIME-TABLE

To be followed in the use of the four different types of portable home canners. The hot water bath outfit is the wash boiler, lard tin or pail with a false bottom.

	Blanch or scald Minutes	Hot water bath outfit at 212°F. Minutes	Water seal outfit above 212°F. Minutes	Steam pressure cooker 5 lb. Minutes	Steam pressure cooker 10 lb. Minutes
Apples (whole)	2	20	15	12	6
Apples (sliced)	2	15	13	10	6
Apricots	1–2	15	12	12	6
Asparagus	5–10	60	60	40	30
Beans, (lima and string)	5	90	60	60	30
Beets	6	90	75	60	40
Blackberries	....	12	10	6	3
Blueberries	....	10	8	6	3
Cherries	....	15	12	10	5
Corn (without acids)..	5–15	240	180	90	60
Grapes	....	15	15	10	6
Grape juice	....	15	15	10	5
Hominy	....	60	50	40	35
Huckleberrics	....	10	8	6	3
Okra	5	60	60	40	30
Okra and tomatoes......	....	50	50	40	30
Oysters	....	50	50	40	30
Parsnips	....	90	60	40	30
Peas (garden and English)	5	90	80	60	40
Pineapples	....	30	25	10	10
Peaches	1–2	15	12	10	5
Pears and plums........	1–2	15	15	10	6
Pumpkins	5	60	60	45	35

	Blanch or scald Minutes	Hot water bath outfit at 212°F. Minutes	Water seal outfit above 212°F. Minutes	Steam pressure cooker 5 lb. Minutes	Steam pressure cooker 10 lb. Minutes
Raspberries	....	15	12	8	5
Sauerkraut	....	50	50	40	25
Sausage	....	60	60	40	35
Sweet potatoes	5	90	75	60	40
Strawberries	....	15	12	8	5
Squash	5	60	60	45	35
Succotash	....	60	60	40	30
Tomatoes	1–2	22	20	10	6
Tomatoes and corn	....	80	70	60	40
Tomato juice	....	20	20	15	10
Turnips	6	90	75	60	40
Quince	2	30	25	15	10
Fish, pork	....	200	200	120	60
Chicken, beef	....	250	240	180	40
Figs	....	30	20	10	5
Spinach	5–10	60	60	40	30
Other greens	5–10	90	90	60	40
Rhubarb	1–3	15	15	10	5
Egg plant	5	60	50	45	30
Carrots	5	60	60	45	30
Cauliflower	5	60	60	40	30

Size of jar. When cooking products in pint or half-pint jars, deduct 3 or 4 minutes from time given above. When cooking in two-quart jars, add 3 or 4 minutes to time. The estimate given is for quart jars.

CHAPTER XI

FARM CROPS AND HOME PROJECTS

If you live in the country you will probably want to undertake some agricultural projects as well as to raise vegetables or flowers. Any farm crop that can be grown in your community will make a project worth while. You will want to find out something about the habits of the plants you decide to grow, for your projects should help you to discover for yourself some of the truths and underlying principles of life as well as teach you how to grow crops for profit.

PROJECT SEVEN

CORN

Material. Grains or corn, flats, plates, and muslin for germination tests.

The kernel. Put a number of corn kernels into slightly warm water and let them soak over night. Examine a dry grain. What is the shape at the tip? Is the crown dented or smooth? How do the flat sides differ? Study a soaked specimen. How do you account for the changes that have taken place? Care-

fully remove the covering from a soaked grain. Looking at the flat sides decide how many distinct parts there are. The oval shaped portion which is light gray in color is the embryo or germ. With a penknife remove the entire embryo using care not to tear it. Lay the rest of the grain aside and examine the embryo. The main part is the cotyledon. On the upper side of the cotyledon find an indistinct slit. Pull it gently apart lengthwise. What do you find on the inside? This rod-like body is the tiny plantlet. It is sometimes called the germ. The end toward the crown of the grain is called the plumule. The other end is the hypocotyl.

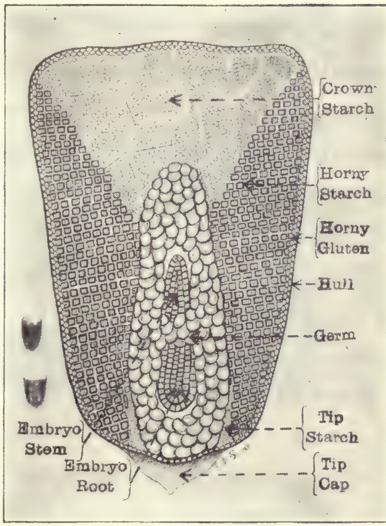

Fig. 30. Structure of a kernel of corn.

Experiment. Which end will make the root; which the shoot? Place several soaked grains on a piece of moist blotting paper or sand. Turn a tumbler or cup over them in order to retain the moisture. A moist piece of cloth will serve as well as blotting

paper. Keep in a warm place. Examine after three or four days.

Which grows more rapidly at first, the root or the shoot? Make a drawing of the young plant and kernel. On one side name the parts of the embryo; on the other the parts of the plant. See Fig. 30.

Endosperm. Examine the portion of the grain that was laid aside. This is called the endosperm. How does it compare in size with the embryo? Take a fresh grain and cut it in two lengthwise across the flat surface. Is the endosperm the same kind of material throughout? How many different kinds do you find?

The function of the endosperm is to furnish food to the plant. To what extent is the plant dependent upon this food supply?

Experiment. Remove the embryo from a number of seeds. Plant them in soil in a flower pot or can. Place in a warm temperature and keep watered. In another pot plant the same number of whole grains. Let them grow side by side for several weeks until you can decide how great the food value of the endosperm is. After four or five weeks dig up a plant that grew from an entire grain and examine the endosperm to see what is left. In what form, solid or liquid, do you find the starchy food material that the plant is using? Where does the plant get food for growth

when the endosperm is used up? See Leaves, page 38.

Germination test. One of the most important things to do, if you are to raise corn, is to make a test of your seed to see whether or not it will grow. There are several ways to do this. The following plan is a good one:

Make a shallow box or flat three or four inches deep. Place about two inches of clean, moist sand in the bottom. Other soil will do equally well if sand

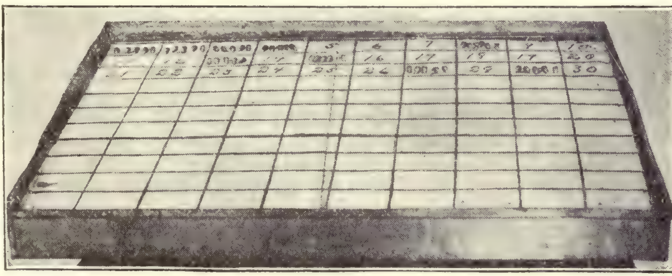

Fig. 31. Corn seed tester.

cannot be procured. With a piece of board make the surface very smooth. With a sharp stick or the end of a ruler divide the surface into squares two and a half or three inches each way. Number the squares from left to right beginning in the upper left-hand corner. See Fig. 31.

The next step is to get the corn ready for the box. Six grains from each ear should be tested. Take two grains from near the butt on different sides of the

first ear. (Do not use the ill-formed grains.) Take two from the middle and two from near the tip. Press them slightly into the sand with the germ side up. Number the ear 1. This may be done by sharpening a small piece of shingle or other thin board, putting the number on it and sticking it into the pith at the butt of the ear. Remove six grains from another ear in the same way, number, and continue until all the squares are full of sample grains. Lay the ears aside where they will not be disturbed. To keep the grains moist, place a piece of old muslin or any cotton cloth over them and put about two inches of moist sand on top. Place in a warm temperature and keep moist.

GERMINATION TEST OF CORN

Ear	Vig.	Weak	Failure	Per cent
No. 1	6			100
No. 2	2		4	33⅓
No. 3		1	5	00
No. 4	5		1	83⅓

The germination box will be ready for examination in four or five days. Begin at one end and carefully roll back the cloth so as not to disturb the grains. Now arrange a table of five columns and place the record of the test in this. In the table the first column indicates the number of the ear. Vig. stands for vigorous. The other terms explain themselves. In the table ear No. 1 shows that all six grains have

sprouted vigorously and the per cent is of course 100. Ear No. 2 has two vigorous sprouts and four failures, hence is recorded as 33 1/3 per cent. When the entire box has been checked up in this fashion, it will be easy to see which ears should be kept for planting and which discarded. What per cent of a perfect stand of corn would you expect to get from ear No. 2? From ear No. 3? etc.

Experiment. Effect of temperature upon germination.

Place grains from the same ear in groups of three or four on moist cloth, blotting paper or sand. Put one group in a refrigerator or other very cool place, another in a moderate temperature, and the third in a very warm place. If possible test the temperature of each place with a thermometer. Watch carefully for results. What is your decision as to the wisdom of planting corn before the soil is warm in the spring?

Preparation of seed-bed. What implements do you use in getting your plot or field ready for the seed? If the ground was plowed in the fall it should be disced and harrowed, perhaps rolled in the spring. It is important that the seed-bed be mellow and well pulverized.

Planting. You must consider the following points in planting:

Distance apart of rows: This varies in different localities from 3 to 4 feet, depending upon the richness of the soil. In the corn belt of the Middle West the regulation distance is $3\frac{1}{2}$ feet.

Distance apart of hills: This is usually the same as that of the rows.

Depth to plant: This depends somewhat upon the condition of the soil. The usual depth is from one and a half to two inches.

Firming the soil: If you use a corn planter and check row, all of the above points will be settled for you. If you plant by hand, you should firm the soil over the seeds with the back of the hoe.

You may live in a region where corn is planted in drills instead of hills. The drills are from 3 to $3\frac{1}{2}$ feet apart; the grains are planted from 10 to 14 inches apart.

Cultivating. What is the purpose of cultivating corn? You have only to think of your study of weeds and of soil water to answer this question. The depth to cultivate depends upon the condition of the soil. A deep mellow soil may be cultivated somewhat deeper than a compact very moist soil. From your study of corn roots you have learned that too deep cultivation will destroy many of the small roots near the surface and injure your prospect for a good yield of corn. It is usually better to keep the field as level

as possible rather than to throw the soil up around the hills. You can keep a better soil mulch to conserve moisture with level cultivation.

Keep the following record of your corn project:

1. Size of plot.
2. Crop raised on plot last year.
3. Time of planting. Time of harvesting. Variety of corn. Disposal of crop.
4. Expenditures.
   a. Cost of seed.
   b. Rental value of plot.
   c. Cost of labor. (Keep record of hours spent and calculate at price paid for such work.)
   d. Cost of fertilizer.
5. Receipts.
   a. Yield of plot in bushels.
   b. Value when sold or used.
   c. Value of other parts of the plant if these are used for feed.
6. Profits.
   a. Yield of plot.
   b. Value at market price.
   c. Net profits.
   d. Net profit per acre.

PROJECT EIGHT

OATS

Material. Samples of oat seeds, plates or boxes for making germination tests.

Study. If you live in a region where oats are grown you may plan to raise a crop of your own. What time of year are oats sown in your community? Do the farmers raise a larger or smaller acreage of oats than of some other crop? Find out the names

of varieties of oats grown. How do you account for the fact that oats may be planted so much earlier in the season than corn?

The grain. Remove the chaffy covering from a grain and note the size, color, and shape. Compare it with a grain of wheat, rye and barley. Compare several different varieties of oats with each other as to size and color.

Purity test. Spread out a small quantity of your sample upon a sheet of white paper. Look closely for foreign bodies of any kind. Put all the weed seeds and trash in one pile and all the oats in another. About what part of your sample is pure oats? How can chaff and light weed seeds be removed from the oats? If you have a fanning mill, run the oats through it. A small amount may be cleaned by holding it high in the air on a windy day and allowing it to fall several feet. A sheet may be spread down to catch it.

Germination test. The most important thing to know about your seed oats is whether or not nearly every grain will germinate and grow. There is only one way to determine this and that is by making a germination test. Count out one hundred seeds from your sample. Place some moist sand or other soil in a dinner plate or box. Scatter the seeds over the sand, not allowing any two to touch. Press the seed

slightly into the sand but do not cover. Now turn another plate over this one or cover with a damp cloth. Keep moist.

How long after planting before the first sprouts appear? Keep watch for two or three days. How many of the seeds fail to sprout? What per cent have sprouted? What percentage of a perfect stand of oats would you expect to get from this seed?

Preparation of seed-bed. The preparation of the seed-bed for your oats plot depends upon what was raised on the ground last year. If the soil was well cultivated, discing or harrowing may be all that is necessary now. If the ground is hard and compact, it should be plowed and harrowed.

Planting. What methods of sowing oats are practiced in your neighborhood? How many farmers use drills? How many use broadcast seeders? How much oats will be required to plant an acre? Some farmers use from three to three and one-half bushels. Others claim that they get a better yield by sowing from one and a half to two bushels.

The chief rule to follow as to time of planting is to sow your oats in the spring as early as the soil can be worked. In the South they are sown in the fall and are known as winter oats.

Oats belonged originally in a cold climate. It is a crop of northern regions, especially of Sweden and

Northern Russia. Some of our best varieties originated in these countries. This is the reason we plant them so early in the spring. Watch to see whether a frost injures the young plants.

Treating for smut. Smut is a disease which attacks oats decreasing the yield in many places from 15 to 25 per cent. You can prevent smut by treating the seed with formalin. (See page 237.) You may be interested to make an experiment. Measure off two tracts of ground of exactly the same dimensions. In one sow oats that have been treated with formalin. In the other sow untreated seeds. When the plants are heading out examine them for smut and determine whether the formalin treatment was effective. If possible get the exact yield from each plot and estimate the loss per acre due to smut.

Observation of growing plants. Watch the habit of growth of the oats plants. When they are six weeks or two months old examine them and determine how many stems grow from one root. What kind of leaves has the plant? Note the plants when they blossom or head out. This kind of branching is called a panicle. If the branches are all on one side, it is called "side oats." Make a careful study of the panicle. Note where the grains are attached. Look in the head for grains of different sizes.

When your crop is about ready to harvest look

through it for heads that seem superior to the others in size and weight. If you are interested in breeding up your oats to a better yield, cut out these heads, thresh them and plant them in a plot by themselves next year. You will in this way get seed enough to plant several acres in a few years and perhaps increase the yield many per cent.

Keep the following record of your oat project:

1. Date of planting.
2. Date of harvesting.
3. Yield of plot.
4. Yield per acre.
5. Expenditures.
    a. Value of seed.
    b. Rent of plot.
    c. Cost of labor.
    d. Cost of threshing.
6. Receipts.
    a. Value of oats at current price.
    b. Value of straw.
    c. Net profits.
    d. Net profit per acre.

PROJECT NINE

WHEAT

If you planted a plot of wheat in the fall, make field observations of the plants. Note the condition of the field at the close of winter. Has any part of it been killed? Dig up a plant and note the length of the root system. If any new leaves have developed

this spring, determine from what part of the plant they grew. Watch occasionally the development and growth of the entire plant, especially of the flowering heads, until harvest. When does the head first appear? Note the change of color that takes place as the wheat matures.

Keep a record of your wheat plot using the items suggested for oats.

CHAPTER XII

TREES

Flowers and leaves. Keep a simple flower record of the trees of your community. Note the date of blossoming; the color and kind of flowers; date of opening of leaf buds. What trees have separate flower and leaf buds? Which have a combination of the two?

Fig. 32. Flowers of the American Elm in April.

Some of the maples and elms blossom very early, long before the leaf buds open. In the South the swamp maple begins to open its beautiful red flowers the latter part of February or the first of March. Farther north the silver and red maples, as well as members of the elm family, blossom the latter part of March or the first of April. These blossoms while very small are wonderfully interesting and should be studied at close range. Some

of them are perfect, having both stamens and pistils; this is always true of the elms. Other trees have two distinct kinds of flowers, staminate and pistillate. None of these early flowers have brightly colored petals.

The growth of trees. Watch terminal buds of several different species of trees as they open and develop. How long is the new part of the twig by the time the leaves are well open? Where do new leaves continue to appear? Compare several species as to the rapidity with which the twigs lengthen. Watch also the development of lateral buds. What do they produce? Compare the growth of twigs from lateral with those from terminal buds.

Fig. 33. Fruit of the American Elm in May.

What other growth does a tree make besides putting out new twigs and lengthening its branches?

To answer this question you should have some cross sections of twigs and branches. If people in the neighborhood are pruning their trees make some sections of different sized branches. Each section should be cut straight across and should be an inch or two in length. If some one cuts down a tree get a few large sections. These may be kept in the school room for years.

Besides the above make some sections of a one, two, and three-year-old twig. Willow or poplar are good for this study. Examine the one-year section first. How many distinct structures do you find? For names see Fig. 35. Peel the bark from some of the fresh twigs. How does the wood underneath look? Rub your finger over it. How does it feel? Examine in the same way the inside of the bark that you removed.

Fig. 34. Flowers of the Norway Maple.

Compare the two and three-year-old sections with those of one year, noting differences. How do the oldest sections that you have differ from the younger ones? What do the rings tell? What indications

are there that the tree grew faster some years than others? How does the bark on the young stems differ from that on the older branches or the trunk? Why is the older bark so rough while the young twigs are smooth? Examine a number of twigs and branches of varying ages to see if you can solve this problem for yourself.

Discussion. The growth of a tree is not limited to the making of new twigs and the lengthening of the old ones. From your study of the cross section

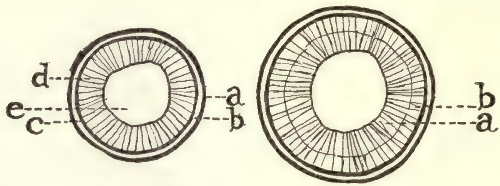

Fig. 35. 1. Cross-section of a twig one-year-old. a, Outer bark; b, Inner bark; c, Cambium layer; d, Wood layer; e, Pith. 2. Cross-section of a twig two-years-old. a and b show the two rings of wood growth.

you know that there is a growth in thickness. Each ring of wood usually shows a year's growth. The growth takes place in the sticky layer that you found between the bark and the wood. This is known as the cambium. Not only does a new layer of wood grow here each year, but a new layer of bark also.

The outer layer of bark does not grow, and when new layers of wood and bark grow on the inside the outside has to stretch. After a time it can stretch

no more and then it cracks. If you look at branches of different ages you see that the cracks grow deeper and more numerous year by year until finally there are the deep fissures that you find in the oldest part of the tree.

Do you know any tree whose bark on the trunk remains smooth until the tree is quite old? What must be true of the growth when this is the case? The bark and the wood grow at about the same rate for a number of years. The wild cherry and the white birch are good examples of this. For a long time the trunk is as smooth as the branches, then little by little the bark cracks and scales, making quite a rough surface when the tree is old.

Fig. 36. Pistillate flowers of silver maple.

If you have a section of a large tree you can probably see a distinct difference between the wood at the center and that toward the outside. The inside portion is called heartwood; the outside, sapwood. The heartwood, after a number of years, becomes dry and hard. It is really dead but it still helps to support and strengthen the tree. However, trees may live a number of years with much of the heartwood

decayed. You have no doubt seen living trees that were quite hollow. Name one or more species of trees in which the heartwood is likely to decay while the tree continues to grow.

The food of trees. Since trees grow they must have food. If you bore a small hole in a maple tree in the early spring, or break the tip off a branch, sap runs out. If you taste this sap you find that it is sweet. Where did it get the sugar that is in it? From your fall study you know it was manufactured last summer by the leaves and was stored in the tree during the winter. You may think of the leaves of trees as factories that make food for the entire tree. The roots take in water and some minerals from the soil which travel upward through the stem to the leaves; the leaves themselves take a gas, carbon dioxide, from the air, and with these raw materials, all day long in the sunlight during the spring and summer, they manufacture plant-food. Some of this is used for growth during the summer, but much of it accumulates in the twigs, stems and roots for future use.

Fig. 37. Staminate flowers of silver maple.

Our native woods. If possible, visit a native woods. Stand under the trees and look up. To what extent do the crowns cover the overhead space? How many different kinds of trees do you find? Which species are largest? Which medium in size? Note the saplings, trees from four to ten or even fifteen feet in height. Are they the same species as the largest or the medium size trees? How numerous are the seedlings, young trees not more than three feet high? What different species do they represent? If the woods are left undisturbed, what species will be most abundant fifty or one hundred years hence? What shrubs do you find growing under the trees? What wild flowers? Examine open spaces. Note what plants are growing there that are not found in the dense woods. How do you account for the difference?

What is the condition of fallen logs or old stumps? Look for branches that have recently fallen. Examine the spots on the trees from which they have dropped. If these trees are used for lumber, the base of every branch will appear as a knot in the boards. From what kind of tree can clear lumber, that is boards free from knots, be obtained?

What use is made of wooded regions in your locality? How many are pastured? Do the stock injure the trees in any way? How many are kept as woodlots by their owners? What different wood products

may a wood-lot well cared for produce? To what extent are the woods in your part of the state disappearing? Are there any tracts in your county that have been set apart for the use of the public? What do you think of the plan of having a few areas of our native woods in every county preserved for all time for the people? They could be used as recreation grounds for the community, but, better than that, for study purposes by all the school children.

Forests and forestry. We usually call small areas of trees woods or woodlands, but the large tracts which are used for lumbering purposes are known as forests. Lumbermen classify the forests into hard wood and soft wood. Hard wood forests comprise the broadleaf trees as walnut, maple, oak, birch and mahogany. Soft wood forests are the cone bearing trees such as pines, cedars and spruces. Your geography will tell you where these various forests are found.

Forests have many enemies such as fires, insects, fungous diseases and wasteful methods of lumbering. The art of cultivating, managing and caring for forests is known as forestry. The forestry branch of the U. S. Department of Agriculture has given much attention in recent years to the better management and care of our great forests. It tries to prevent fires, to combat insect pests, and to introduce the

best methods of lumbering, so that by the conservation of the young trees the lumbering industry may be kept permanent. It is also attempting to raise timber crops in treeless regions of the West.

Uses of trees. What are trees good for? You have only to look around in your home and school to realize how very useful trees are. Make a list of all the things in and about your home, school, church, stores, street, and farm that are made wholly or in part from the wood of trees. Make a second list which includes trees that furnish food of some kind. Make a third list in which you include the value of trees in affording you and other people pleasure.

The first and second lists give you some idea of the great value of trees in the industrial world. They not only furnish quantities of food and the vast amount of materials used in buildings, furniture, machinery, paper, etc., but at the same time they afford employment to thousands of people in lumber regions, in factories, in carpentry, in paper mills, etc. Your geography will tell you something of the great centers of these activities.

The third list helps you to appreciate the value of trees in your own life. They afford shade and shelter, provide nesting places for birds, and make our homes, public school grounds, and the entire landscape beautiful. Why do artists so commonly

put trees into pictures? Where are trees most beautiful to you?

Trees on home grounds. Study the trees about your homes and other places in your neighborhood. How many of them are native trees? How did they happen to be there? Did they grow wild or were they planted? Which of them do you like best? Is there any one tree in the neighborhood that you consider especially beautiful? If it is an old tree, find out all you can about its history. What street or road has the most beautiful row of trees? Which do you think is more attractive, a street planted the entire length with one species of tree, or one planted with a number of species?

Select the home in your community that has its trees arranged to give the most beautiful effect, an effect that makes the trees and buildings look as if they belong together.

Planting trees on home grounds. Trees about a home may add much or little to its attractiveness according to the trees used and the manner in which they are set out. Simple rules to follow in planting home grounds are: 1. Choose hardwood, long lived trees, not the shorter lived, more rapid growers. With a few rare exceptions choose native rather than foreign trees. 2. Place the trees at the sides and rear of the house, not in front. You do not want

them to screen the building, but rather to make a background and natural setting for it. 3. Let the height of the building help to determine the species of trees to use. Cottages and bungalows to make a pleasing landscape picture should have low trees

Fig. 38. Spraying large trees.

nearby. On the other hand, high buildings require some tall trees to frame them in.

Care and protection of trees. You should be interested in trying to keep the trees in your community in as good a condition as possible. Trees need care and protection, and while you may not be able to do much active work you can do something. Make a simple survey of the trees in your block or district

to find out whether or not they need attention. How many do you find that have been injured in some way? Determine, if possible, what caused the injury. Are any insects feeding upon the trees? Look on the bark for scales. Examine the old trees for unhealthy conditions as shown by decaying spots or fungous growths. Look for dead branches that should be cut out. Do you find guards around young trees? Are there any that should be protected in this way but are not? Report what you find to your teacher or to the officer whose business it is to look after the welfare of the trees. Another thing you may do is to be careful not to injure trees yourself. Avoid swinging on young trees or breaking off twigs and branches. You may help to work up a sentiment in your neighborhood that will go far toward making other people, both children and adults, take a greater interest in caring for the trees.

PART TWO

FALL STUDIES

CHAPTER XIII

INSECTS

Material. Insects of the garden, orchard, fields and home; wide-mouthed bottles or tumblers; several pint and quart jars; a flower pot with a lantern globe or lamp chimney; a wire cage or vivarium; a small hand lens.

A vivarium. For the foundation of this use a shallow box a foot and a half or two feet long, six inches wide and three inches deep. Nail upright in each corner a flat piece of board fifteen inches high, about an inch wide and half an inch thick. Complete the frame by nailing pieces of board to the top of the uprights. Cover the sides with wire screen or mosquito netting, and place a board or pane of glass on the top for a cover. See Fig. 39.

A simple cage may be made from an ordinary shoe box. Cut rectangular pieces out of the top and bottom and sew in wire screening or mosquito netting,

tying a string around the box to keep the lid on. Stand it on one side and you can easily watch the movements of insects within.

If you wish to make a collection of insects, a cyanide jar is necessary. To make one place five cents' worth of cyanide of potassium in the bottom of a wide mouthed bottle or pint fruit jar. Handle the

Fig. 39. A vivarium or insect cage stocked with insects.

cyanide very carefully; do not touch it with your fingers. Make a stiff paste of plaster of Paris and water. Pour this over the cyanide, covering it about an inch or an inch and one-half in depth. Allow the bottle to stand open two hours, then close it tightly and keep closed except when putting insects in or taking them out. Label the jar POISON.

Garden pests. Make a list of all the insects you

have found in your garden this season. Choose for detailed study any that you find on your plants now.

The cabbage worm. Look on cabbage plants for worms or larvae. On what part of the leaves are they? What are they doing? How many different

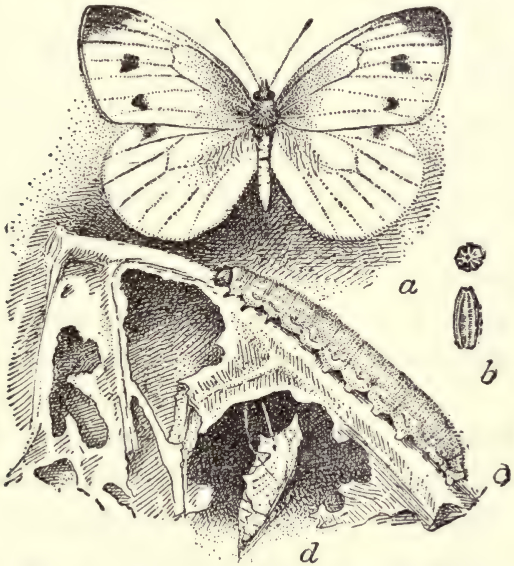

Fig. 40. The common cabbage worm (Pontia rapae). a, Female butterfly; b, Egg; c, Larva, or worm, in natural position on cabbage leaf; d, Suspended chrysalis, or pupa.

sizes are there? Do they look as if they were all the same species? Collect a number of leaves with the worms on them and place them in a box in the school room for further study. Look carefully at one larva and note everything that you see. Describe the body

covering. What is the number of feet? How do the feet on different parts of the body differ from one another? What are the uses of the different kinds?

Watch a larva feeding. How does it eat? What kind of mouth has it? Determine this by observing the partially eaten leaves. Put several larvae into a box or insect cage and give them fresh leaves every day. Watch for changes. Describe the new form. This is called a *pupa*, the plural is *pupæ*. Determine how the pupa is attached to the box. Examine it with your lens and describe what you see. Keep the box with the pupae so that you may later see the adult insects.

If you have two kinds of larvae compare them noting differences. How do they differ in the pupa stage?

The butterfly. Watch white butterflies hovering over the cabbage plants. What do they seem to be doing? Look very closely on the leaves especially on the under side for eggs. These are small cream colored specks that stand up on end. Examine one with your lens and describe it. Capture a butterfly, place it in a clear glass bottle and note its colors, the number of feet, the wings, the kind of antennae, (feelers) and the mouth.

Are cabbage-worms very destructive? What methods of combating them do you know?

Discussion. If you saw all the legs of the cabbage-worm, you noticed three pairs of rather pointed ones near the head, four pairs of wide ones near the middle, and one wide, flat pair close to the hind part of the body. The three near the head are called true legs; all of the others are prop legs. The prop legs are used for clinging as well as for crawling.

Cabbage-butterflies lay their eggs upon cabbage leaves. These hatch into small larvae which have jaws or biting mouths with which they nibble holes in the leaves. When they are ready to change into pupae, they fasten themselves to some object by means of a few silk threads bound about the middle part of the body. Then they shed their skins and become pupae. During the summer and early fall the insect remains in the pupa stage from a week to ten days. Those that pupate late in the fall remain in this stage all winter. When the pupa changes to a butterfly, the skin splits along the back and the butterfly emerges. The pupa skin, as well as the pupa itself, is often called a chrysalis.

If you had two kinds of larvae, you found that the one with prominent sections, when it went into the pupa state, spun a thin white cocoon and changed to a dark brown pupa. This larva produces a cabbage-moth instead of a butterfly. It remains in the pupa stage about ten days and then emerges, a small,

dark-colored moth, the kind that people often call moth millers. Compare the moth with the butterfly noting differences.

Tomato-worm. If you have tomato plants, you may find larvae of the tomato sphinx-moth on them. Study these as you did the cabbage-worm. If you wish to watch them through their life history, you must provide soil in which they may pupate. Fill a fruit jar about half full of garden soil. Firm it down, then place the worm in it with tomato leaves for it to feed upon. When the larva is ready to pupate it pushes down into the soil, makes a mud cell perfectly smooth on the inside, then sheds its larva skin and becomes a pupa. Sometimes when you spade up your garden in the spring, you find the brown pupa of the tomato-worm. It has a loop on one side which resembles a handle. This is a case for the long sucking tube of the moth. Set the jar in which the worm has pupated in a cool place and occasionally moisten the soil a little especially in the early spring. Place a small twig in the jar to which the moth may cling when it emerges from the ground. These moths appear from April until the latter part of May or even June, depending upon the latitude.

You have probably discovered that while the larvae of moths and butterflies have biting mouths with which they eat leaves, the adults have sucking mouths

and feed upon the nectar of flowers. Many moths are quite as beneficial as bees in carrying pollen from one flower to another. All butterflies and moths have the same kind of life history as the cabbage-worm and the tomato-worm. They have four distinct stages: the egg, larva, pupa and adult. Insects that make this complete change in their form are said to have complete metamorphosis.

Squash-bug. Look on your pumpkin and squash vines for a flat, dark gray insect a little more than half an inch in length. Where on the plants do you find them? What are they doing? Visit the plants early in the morning, again during the warm part of the day, and in the evening. How do the insects differ in their behavior at these different times? How many stages of development do you find among them? How do the young differ from the adults? Place some of the young in a jar with a few fresh leaves and keep them for a few days. What happens? How do they accomplish the change? Look in the jar for cast-off skins.

Examine the front part of the head of the adult squash-bug for the mouth. How far back does the sucking tube extend? How is this used in procuring food? Place a few of the insects in a fruit jar with squash or pumpkin stems or a small piece of the fruit. Watch them eat. Describe the wings of the

insect. About what portion of one overlaps the other? Look for inner wings. Is the squash-bug as great a flier as moths or butterflies?

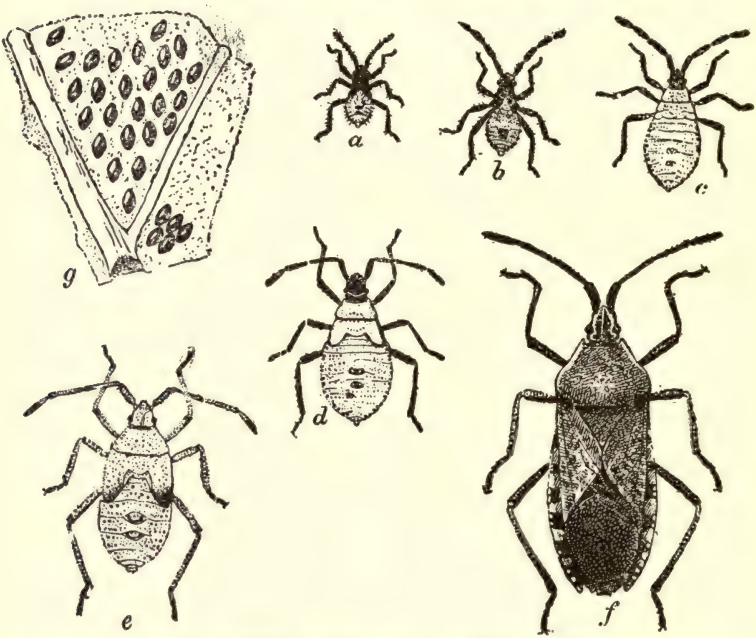

Fig. 41. The common squash-bug (Anasa tristis). a, Newly hatched nymph; b, Second stage nymph; c, Third stage nymph; d, Fourth stage nymph; e, Fifth stage nymph; f, Adult; g, Egg mass. (All about twice natural size.)

Aphids. Look on the leaves of cabbages, turnips, nasturtiums or other plants for small plant lice called aphids. Some lie flat, others resemble tiny flies. Examine them carefully and note the number of stages represented. How do the winged individuals differ

from the wingless? What kind of mouths have they? To determine this, hold the leaf on a level with your eye so that you can see under the insect and find the sucking tube inserted in the leaf. Are there any other insects among the aphids? If so, what are they doing? (See Beneficial Insects, page 223.) In what respects do aphids resemble squash-bugs?

Discussion. The squash-bug differs from moths and butterflies in that it does not have the four complete stages in its development. The young when it hatches from the egg has the same form as the adult except that it is smaller and lacks wings. As it grows it sheds its skin or molts. After the second molt, the wings appear as little flat pads on the back. After the last molt the wings are fully developed. Insects that have this kind of a life history are said to have incomplete metamorphosis. The young are called nymphs.

Aphids have the same kind of mouths as squash-bugs; that is, a piercing sucking tube. They also have incomplete metamorphosis, but they do not have the same kind of overlapping wings. They are among the most destructive of pests. Few plants are free from them. They have a life history differing from most other insects.

One of the most destructive of these insects is the corn-root aphis, which feeds upon the roots of corn.

Its life history is similar to that of all other aphids except that the eggs of all are not cared for by ants.

The female of the corn-root aphis lays shiny black, oval eggs in the ground during the fall months. Little brown ants find these, carry them to their underground homes, and keep them safe through the winter. They often carry the eggs out into the sunshine during the warm part of the day and back into the burrows at night. These eggs hatch in the early spring into young aphids. The ants at once place them upon the roots of smart weeds or some other plant. When corn is beginning to grow, the ants place the aphids on the corn roots, from which they suck the juices with their sharp sucking tubes. The ants get their pay for all this work in the form of honey dew, a sweet substance which the aphids throw out of their bodies.

Each aphid that hatches from an egg in the spring is called a stem-mother. In less than a month this stem-mother begins to reproduce young. All these are females which in a month's time begin also to produce young. So in less than two months the stem-mother may become the ancestor of thousands of young lice. This goes on all summer.

Most of the aphids are wingless. Once in a while there is a generation that has wings. These fly away to some other part of the field or to another field.

Some of them drop to the ground, and are found by ants which carry them at once to the corn roots. In the fall a brood of males and females is produced. These females are the ones that deposit eggs for the new stem-mothers next year. You can readily see why the destruction of the ants' homes should be encouraged.

One of the methods employed to destroy these pests is to break up the ground as early as possible in the spring, and then before corn planting go over it once or twice with a disc or cultivator in order to destroy the smart weeds and as many of the ants' nests as possible.

Cucumber beetles. During the fall you may find in the flowers of squash or pumpkin and on some of your flowering plants small cucumber beetles. Often there are two species; one a dull green spotted with black, the other with black and yellow stripes. Determine if possible what the beetles are doing in the flowers. Capture some of them and find out all you can about them. How do they compare with other insects studied as to hardness of body? How many legs have they? How many pairs of wings? How are the outside wings placed in relation to each other? How do the inner ones compare in length with the outer? What kind of a mouth has the beetle?

Discussion. Cucumber beetles are among the worst

garden pests. They are very destructive to cucumber plants as well as to melons of all kinds. They do most of their mischief in the larva stage. The adult beetles in the fall are fond of pollen. That is why you find them feeding in the flowers. They hide away during the winter under leaves or other rubbish and come out about the time the cucumber plants and other cucurbits are beginning their growth. They

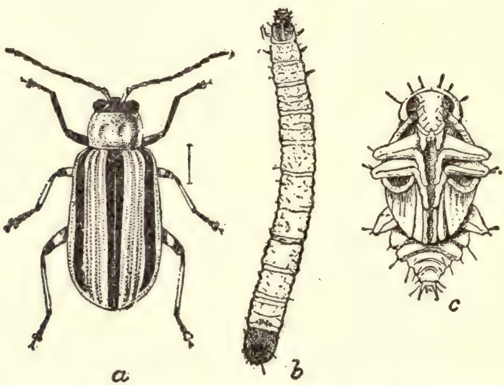

Fig. 42. The striped cucumber beetle (Diabrolica vittata). a, Beetle; b, Larva; c, Pupa. (Much enlarged.)

visit the plants for two purposes; to feed upon the young leaves, and to lay their eggs at the lower part of the stem. The eggs hatch into worm-like larvae that bore into the stem and roots, often killing the plant.

Like all beetles they have biting mouths, hard outer wings that meet in a line down the middle of

the back, and membraneous inner wings that are used for flight. These wings are longer than the outer ones and when not in use are folded back under the protective hard ones.

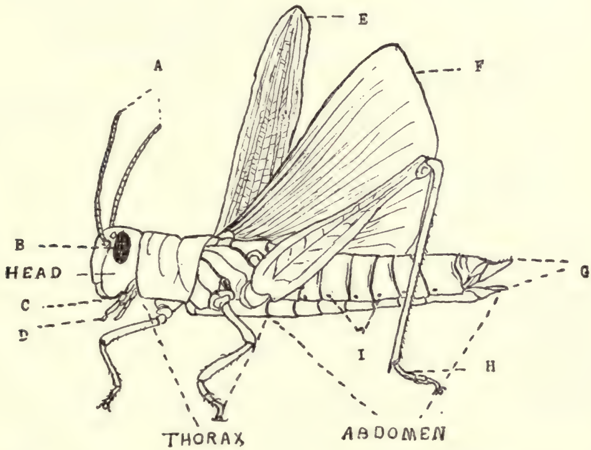

Fig. 43. Parts of an insect: A, Antennae; B, Compound eye; C, Mouth; D, Palps; E, Outer wing; F, Inner wing; G, Ovipositor; H, Foot; I, Spiracles or breathing pores.

While we have chosen for study types of insects that are likely to be found in gardens, you should make an effort to get acquainted with other insects that are found about your home, school and farm.

Use the following outline in keeping a record of your insect studies. Keep any larvae that you find in glasses or boxes, feed them and watch their development. In most cases the plants upon which you find the insects will determine what to feed them.

Insect Record

1. Name:
2. Stage of development: larva, pupa, adult, or, if an insect with incomplete metamorphosis, nymph.
3. Where found:
4. Characteristics:
    a. Size—small, medium, large, or length in inches.
    b. Body covering—hairs, spines, smooth skin, etc.
    c. Color or colors.
    d. Antennae—long, short, hair-like, elbowed, knobbed, feathery, scaly, etc.
    e. Eyes—large, small, position.
    f. Legs—number, special features.
    g. Wings—number, special features.
5. Habits: movements, active in daylight, at night.
6. Kind of development: complete metamorphosis, incomplete metamorphosis.
7. Pest, benefactor or neutral.
8. If pest, how controlled. If benefactor, what does it do that is beneficial?
9. Remarks. Any facts of interest not noted above.

Insects and health. The house-fly and the mosquito are of special interest because they carry contagious diseases from one person to another.

Mosquitoes. Mosquitoes breed in standing water. You may find the young, or larvae, in pools, ponds, rain barrels and tin cans that have been thrown into the rubbish heap and are partly filled with water from rains. If you find any of the larvae (a common name for them is wrigglers) place some in glasses of water and watch them. Determine how they move about, how they breathe, and how they eat. Tie netting over some of the tumblers and keep till the

insects change to the adult mosquitoes. Place a small amount of kerosene on the surface of the water in one tumbler and note the effect.

The mosquito larvae that you find abundant in rain barrels, tin cans and pools belong to the genus called Culex. There are a number of different species of these, some much larger than others.

If you observed the larva carefully you noted that when at rest it remains near the surface of the water with the head end extending obliquely downward. At the back part of the body is a small tube-like projection which reaches the surface of the water. This is the breathing tube, so, although the insect lives in water, it breathes the air above the water. Around the mouth the brushes of hair that you see constantly moving are making a current of water which brings food to the larva. It eats tiny one-celled plants and animals and bits of decaying matter. It remains in the larval stage from five to ten days according to the temperature. The warmer the weather the more rapidly it grows.

You probably noticed that some of the wrigglers differ from the larvae. They are darker and the front part of the body is thick and curved. Each of these is a pupa. The pupa breathes by means of two tube-like projections on the back, so it floats in the water with the head up instead of down. It does not eat

in this stage. In from five to seven days the pupa skin splits open along the back and the mature mosquito works its way out. It floats a short time upon the empty skin while the wings are drying, then it flies away. By putting mosquito larvae into a jar of water and tying cheese cloth over the top you can work out the entire life history.

The Culex mosquitoes, so far as known, are not dangerous; that is, they do not carry diseases. They are, as everyone knows, exceedingly annoying.

It is only the female that bites and sucks blood. The male feeds upon the nectar of flowers. The humming sound made by the mosquito is produced by the vibrations of the wings.

The Anopheles mosquito is more than annoying. It transmits malaria of all kinds; hence it is often called the malaria mosquito. The larva differs from the Culex in that it floats almost parallel with the surface of the water instead of obliquely. The pupa is very similar to that of the Culex. The adults of the two kinds are somewhat different. The Anopheles have dark spotted wings. The Culex when resting on a wall remains with the body straight; the Anopheles holds the hinder part of the body away from the wall thus making an angle. Culex mosquitoes are to a certain extent active during daylight. Anopheles are active only after six o'clock in the evening.

How mosquitoes transmit malaria. The malaria germ is a tiny one-cell animal that passes through one stage of its life in man and another stage in the body of the mosquito. In man these germs live in the red blood corpuscles, feeding upon them. When a germ reaches a certain size in the blood corpuscles it divides into a number of distinct individuals, which float about for a while in the blood, then again enter the corpuscles and go through the same process of division.

If a malaria mosquito sucks blood from an infected person, a large number of these small germs called spores are taken into the stomach of the mosquito. Here they undergo certain changes and then pass through the wall of the stomach into the body. They finally reach the salivary glands. If now the mosquito bites a person who is free from malaria, some of these germs flow with the saliva into the blood. They enter the corpuscles, feed and multiply and cause chills and fever or some other form of malaria.

So far as is known this is the only way that malaria is transmitted; that is, it can get from one person to another only through the agency of mosquitoes. Sometimes, however, the spores may remain inactive or dormant for a long period in the blood of a person who has had malaria, then suddenly become active and produce the disease.

It is very evident that all that is necessary to eradicate malaria is to get rid of malaria mosquitoes. Since these insects breed only in water it is not a difficult task in most regions to exterminate them. Draining ponds, covering pools that cannot be drained with crude oil or kerosene, screening rain barrels and preventing the accumulation of tin cans or other rubbish, will in a short time entirely rid a community of these pests. The fact is, that in many parts of the country they are already kept well under control.

Where drainage is not possible kerosene may be used to kill the larvae and pupae. The oil spreads over the surface of the water making a thin film on top. The insects cannot penetrate this with their breathing tubes so they are entirely shut off from air and soon die. This method has been used extensively in some of the swampy regions of the East and has proved very effective.

Yellow fever is transmitted from one person to another by the yellow fever mosquito in about the same manner that malaria is. The disease has decreased remarkably during the last ten years because the mosquitoes are not allowed to breed as formerly.

House-fly. The house-fly is even a greater menace to health than mosquitoes. Capture a house-fly, put it in a glass or bottle and examine it. Describe its eyes, wings, legs. Put a bit of sugar or some other

food in the glass and watch to see how the fly eats. The long projection that you see is the tongue. This is used to lap up liquid food. When the fly eats a hard substance like sugar it first moistens it and then laps it up.

The life history of the fly is familiar to almost everyone. It has complete metamorphosis, passing through the four stages from the egg to the adult in less than two weeks. Its chief breeding places are

Fig. 44. The common house fly (Musca domestica), showing puparum, adult, and larva. (All enlarged.)

stable manure, outdoor closets and other places where there is an accumulation of decaying vegetable or other organic matter.

The eggs, during the warm summer months, hatch within twenty-four hours after they are laid. The larvae are known as maggots. They are white in color and feed ravenously upon the food material with which they are surrounded. In from five to seven

days they reach their full size as larvae; they then crawl out of the food material into a dry place where they change to pupae. A pupa is brown in color and about as large as a grain of rice. The pupa stage lasts from four to six days in hot weather. In cool weather it may last ten or twelve days or it may remain in this stage over winter. The adult then emerges and in a few days is ready to deposit eggs. Each fly lays from two hundred and forty to four hundred eggs.

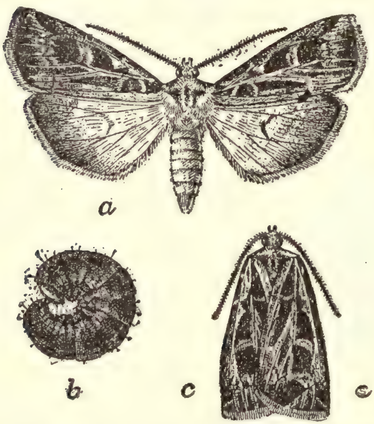

Fig. 45. The dingy cutworm (Feltia subgothica). a, Moth or adult, with wings expanded; b, Larva, or worm, in curled-up position when feigning death; c, Moth with wings folded. (Somewhat enlarged.)

For a long time it was supposed that house-flies spend the winter only in the adult stage, but recent experiments seem to show that probably most of them pass the winter in the pupa stage.

There is little question that the house-fly is a carrier of typhoid fever, dysentery, cholera and tuberculosis. It carries the germs of these diseases on its sticky feet and on the hairs of its body. When it alights on food, as it often does, some of the germs

may be dropped and afterward eaten with the food and thus start a disease.

Flies may be exterminated from any community if all the people work together. It will be worth while for you to aid in starting a fly campaign in your district. There are several things that may be done. First, it is absolutely necessary to get rid of all the breeding places. Second, use traps of various kinds. Place some of them out-of-doors, at some distance from the house near barns and chicken yards. By using attractive bait, and by keeping other sources of food such as scraps and all garbage cans covered, you can succeed in catching every fly in the district. Some of the best baits are milk, banana, and bran mixed with sweetened water. Traps should be set early in the season when the flies are awaking from their winter sleep. In this way they will be prevented from depositing their eggs and starting a new generation. You may make traps for yourself with little cost.

List of Common Pests

Garden pests not discussed above. Larvae of black, swallow-tail butterfly found on parsley and parsnips. Usually they may be considered neutral since they are not abundant enough to do much harm. The Colorado potato beetle. The corn ear-worm which feeds upon the ears of sweet corn, also upon field corn. Strawberry leaf-roller. White grubs, which are larvae of May beetles and feed upon the roots of numerous garden plants. Cut-worms, which feed upon stems of young plants, cabbages, corn, etc., cutting them off close

to the ground. The adult is a moth. Currant and gooseberry-worm. The adult is a sawfly.

Field pests. Grasshoppers feed upon grasses, clovers and corn. Army-worms upon oats, wheat and corn. Corn-root aphis. Corn-root worm. White grubs upon roots of grass and corn. Chinch-bugs upon wheat, oats and corn. Hessian-fly upon wheat. Cut-worms. Wire worms, which feed upon corn. Cotton-boll worm and cotton-weevil, which feed upon cotton.

Fruit tree pests. Coddling-moth, canker-worm, woolly aphid, San Jose scale, scurvy scale, apple-tree borers, tent caterpillars, the peach-tree borer, plum curculio, bark beetles.

Enemies of forest or shade trees. Fall web-worm, catalpa sphinx, elm leaf-beetle, aphids, leaf rollers, bag-worms, bark beetles, scurvy scale, oyster-shell scale, San Jose scale, white marked Tussock-moth, gypsy-moth, brown tail moth, elm sawfly, bronze birch borer, locust borer.

Household pests. Cockroaches, ants, clothes-moths, flour-worms, mosquitoes, stable-fly, house-fly, carpet-beetles, corn-meal moth.

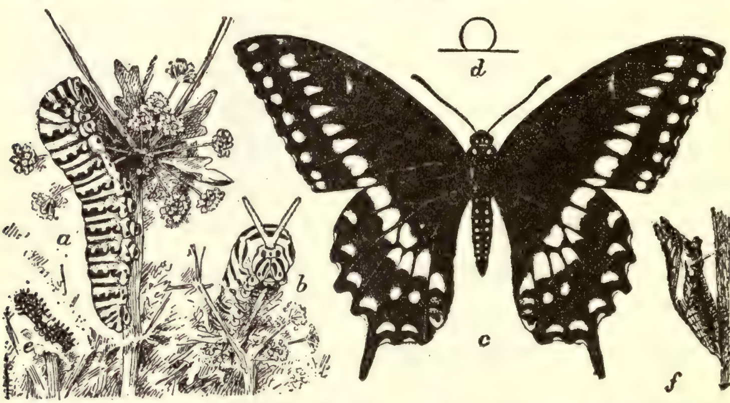

Fig. 46. The celery caterpilar (Papilio Polyxenes). a, Larva from side; b, Larva showing head with odoriferous appendages; c, Male butterfly; d, Outline of egg; e, Young larva; f, Chrysalis. (All about natural size except d, which is much larger.)

Insects with biting mouths may be controlled by poisons placed upon the plants upon which they feed.

Insects with piercing, sucking mouths cannot be destroyed in this way since they feed from the inside of the leaf or stem. They may be controlled by spraying with insecticides that kill them by coming in contact with their bodies. Those most effective are kerosene emulsion, kerosene and water, whale-oil soap, lime-sulphur mixture, and Black Leaf No. 40.

Recipe for poison sprays. Arsenate of lead is largely taking the place of other poisons for biting mouthed insects. It may be bought in the form of a paste ready to dilute. Directions for mixing are on the package. One pound of the poison may be mixed with about sixteen gallons of water. Paris Green has been a favorite spray for biting insects for years. The standard formula for the mixture is:

4 ounces of Paris Green
½ pound of lime slaked
50 gallons of water
(Many people use it without the lime.)

Slug shot is a powder that contains poisonous mixtures. It is sifted upon the plants and for small gardens is quite effective.

Lime-sulphur like arsenate of lead may be bought in packages ready to dilute. It is excellent for aphids and scale insects. It is effective also in destroying certain fungous diseases as blight.

Beneficial Insects

You must not think that all insects are pests. Many of them are real benefactors. You already know something of the value of bees in making honey and in carrying pollen from one flower to another. To some extent this is true of moths and certain wasps. You know, too, the value of silk worms in producing the silk of the world. There are other insects that benefit us in quite a different manner, that is, by destroying some of the insect pests.

Ladybird beetles. Ladybird beetles or ladybugs are among the most beneficial insects. Look on any plants infested with aphids and you will be almost certain to find ladybugs both in the adult and larva stages. Capture a few of the adults and place them in a glass with some leaves on which are a number of aphids. Watch to see what they do. Examine a ladybird closely and decide why it is more correct to call it a beetle than a bug. What kind of wings has it? If you find any of the young, or larvae, place them also in the glass and feed them on aphids. After a few days they will pass into the pupa stage. Note how they fasten themselves to a leaf or a stem. Keep the pupa, and in a week or ten days the grown-up beetle will appear.

There are a number of different species of lady-

birds that are common everywhere. Most of them are brightly colored, either red or yellow with black spots. All of them pass the winter in the adult stage. Often you will find them congregated in great numbers under a shrub or hedge during the winter months.

Ladybirds and their young not only eat aphids but eggs and larvae of potato beetles and many other injurious insects. They aid more than we can estimate in keeping pests in check. In California they are especially helpful in destroying scale insects that feed upon orange and lemon trees.

Braconids and Ichneumons. When you studied cabbage worms perhaps you found that some of them, instead of pupating, died and had clinging to their bodies a cluster of yellow cocoons. Each of these cocoons had in it a small pupa. If you should place the pupa in a glass with a cover over it, in the course of about two weeks you would find the glass full of small insects not larger than gnats, which had emerged from the cocoons. They are the adult insects and are called *braconids*.

If you could go back through the life history of this insect, this is what you would find. Some time during the summer the adult braconids deposit their eggs under the skin of the cabbage-worm. Each egg hatches into a small larva which feeds upon the fluids in the body of its host. When it is ready to change

to a pupa, it breaks through the skin of the worm and spins its cocoon within which it changes to a pupa. Usually the entire number within the worm come forth at the same time killing it instantly.

The braconids destroy hundreds of cabbage worms every year. If you look closely at one of the adults, you will see that it has two pairs of membranous wings and that its body is somewhat wasplike. In fact, the braconids belong to the same group of insects as the bees and wasps.

Sometimes you find tomato-worms or grapevine sphinx larvae almost covered with white cocoons. These belong to another species of braconids that live in the bodies of these insects. A tomato-worm infested with braconids, while it may not be killed outright as in the case of the cabbage-worm, never lives to become an adult moth. In some localities the braconids keep the tomato-worms in check to such a degree that no other remedy is needed.

You may find among aphids some dead ones that have hard, swollen bodies. Some of them have a small round lid cut in one side. These aphids have been killed by still another species of braconid. The little creature remains inside the aphid while it passes through its entire life history. When grown up it cuts a hole in the side of the body and comes forth. Braconids are called parasites because they live and

feed in the bodies of other insects. The insects in which they live are called hosts.

Another group of parasites is known as *ichneumons.* These are somewhat larger than braconids. Certain ichneumons destroy hundreds of Tussock-moths which are so destructive to our shade trees. Others destroy tent caterpillars that feed upon our apple trees, and a few destroy the gypsy-moth, which is one of the worst tree foes we have.

There are a number of other beneficial insects that you will want to get acquainted with as soon as possible. Among them are: 1. The larva of the lace-wing fly, called the aphis-lion because it devours so many aphids. 2. Dragon-flies which feed upon mosquitoes and gnats. 3. Tiger-beetles which kill off ants and some other ground insects. 4. Several species of ground bettles that feed upon caterpillars; chief among these is the beautiful green and blue searcher which destroys the corn-ear worm. 5. Many of the water beetles kill off great numbers of mosquito larvae. 6. The praying mantis kills weevils, cottonboll worm, and other caterpillars.

CHAPTER XIV

FUNGI

Material. Mushrooms, toadstools, puffballs, bracket fungi, mold, smut and rust on wheat, oats, and corn.

Fungi is the name of a large group of plants including mushrooms, toadstools, molds and many fungous growths found on plants and animals.

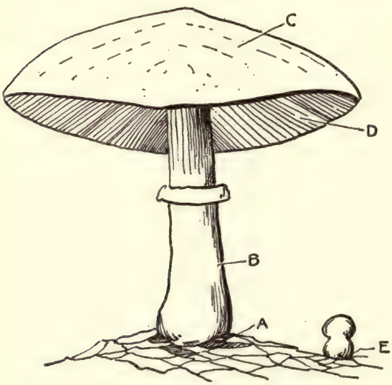

Fig. 47. A common mushroom: A, The mycelium; B, The stem or stipe; C, The pileus; D, The gills which bear the spores; E, The young stage of a mushroom.

Mushrooms or toadstools. Find some mushrooms or toadstools. Where are they growing? If there are a number, look for different sizes or stages of development. What is the condition as to moisture of the soil or other substance upon which they are found? Collect some for indoor study. Try to get a little of the substance upon which they are growing. Examine one of the mushrooms. How many dis-

tinct parts has it? Look very closely at the soil to determine whether a part of the plant is in this. (See Fig. 47 for the names of the parts.) What do you find on the under side of the cap or pileus? The leaflike bodies are called gills. To determine the use of the gills cut the stipe out close to the pileus. Lay the pileus, gills downward, on a sheet of white paper. Place it where it will not be disturbed. After twenty-four hours carefully lift the pileus. What do you find on the paper? The powder is composed of spores. These are the reproductive bodies. They produce new mushroom plants just as seeds produce corn or wheat. What is the color of the spores? What does the print indicate as to where the spores are borne?

Compare the young stages of the mushrooms with the older ones noting differences. If the weather is warm, watch their development. How rapidly do they grow? How long do they remain in good condition after they are fully grown?

Look for different kinds of mushrooms and toadstools. Compare as to shape, size, and color. Make spore prints and note differences in size and color of spores.

Puffballs. Where do you find puffballs growing? How large are they? Is the mycelium more or less easily found than that of mushrooms? Cut one in

two and describe the inside. How does a mature one differ from a young one? If you find no mature ones, lay some aside until they dry. Are there many or few spores?

Discussion. From your observation you have probably concluded that mushrooms, toadstools and puffballs are found in places where there is plenty of moisture and some sort of decaying vegetation. The fact is that these plants and all other fungi are dependent upon seed plants for their food. Since they do not have the green coloring matter found in leaves, they cannot manufacture their own food. This is why you find them growing among decaying leaves, stumps or logs. Some of them are found in meadows which are rich in decaying grasses. Some are found in the rich, decaying matter around barns.

The thread-like mycelium penetrates the soil or other substance and procures the food. The part that is above ground grows up for the purpose of producing the spores. It is called the fruiting body. The spores of mushrooms and toadstools are produced on the free edge of each gill; those of puffballs are borne inside the ball. The mycelium may grow for weeks or months before it sends up the fruiting body. During dry or cold weather it may remain alive but inactive for months; then when the proper conditions come, it grows rapidly and sends up the spore bearing body.

From this you can readily see that the spores when they germinate and grow produce the mycelium.

Mushrooms are of interest because they furnish human food. Some are edible; others are poisonous. The poisonous ones are frequently called toadstools. Many people raise edible mushrooms for market and for canning. Others collect them for table use from the woods and meadows. These people have learned to recognize certain edible species. If you wish to collect mushrooms for food, the best plan is to take a specimen to some person in the neighborhood who knows which ones are edible. There are some general characteristics that will help you to distinguish the edible from the poisonous kinds.

1. Some of the most deadly ones have the lower part of the stem surrounded by a cup-like membrane. So you should always dig down far enough to be sure that no cup is present.

2. Avoid mushrooms covered with scales.

3. Poisonous species are likely to have white spores; edible ones dark spores.

4. Avoid those with milky juice or with shiny caps.

5. Do not eat them after the meat has turned dark.

All puffballs are edible although the flavor is not always as delicious as that of most mushrooms. All the precaution that is necessary in collecting these

for food is to be sure that they are puffballs and not young stages of poisonous mushrooms.

Bracket fungi. Look on trees, stumps or logs for bracket fungi. What kind of trees do you find them on? On what part are they growing? Are the trees alive or dead?

Examine one of the brackets. Compare the upper and under surfaces. Look for layers of growth. On which surface do they show more distinctly? Examine the lower surface with a lens and describe it. Cut a section through the fungus and determine how far you can trace the small tubes. Cut off a bit of bark with some of the younger specimens attached and look for the mycelium, a mass of white threads at the base of the fungus. If the tree is dead, slice off a piece of bark to determine whether or not the mycelium penetrates the wood.

Make a collection of bracket fungi. They may be dried and mounted by means of pins in shallow pasteboard boxes.

Discussion. The spores of bracket fungi are borne in the tiny tubes whose openings you found on the lower surface. The spores drop out, are carried by the wind, settle upon trees, stumps, etc., where they germinate and grow. The mycelium penetrates the wood feeding upon it. Usually these fungi are found upon dead trees, logs and stumps which in time they,

with the other fungi, reduce to mere vegetable mold in the soil.

Some species, however, are found feeding upon living trees. Occasionally they kill the entire tree; but usually they only injure some of the branches. However, the spores cannot find access to a tree unless there are wounds in the bark. If a tree receives an injury in any way, the wound should be cared for at once. A coat of paint is excellent for this.

Mold. Mold is a fungus that is frequently found in our homes. About a week before you are ready to begin this study, moisten a piece of stale bread, put it on a piece of pasteboard, and turn a tumbler over it to prevent it from drying. Keep it in a warm place but not in a strong light, and look at it occasionally. When there is a good crop of mold, examine it carefully. What color or colors do you find? How many distinct parts are there? What do you think the threads are? The little white or black balls? To what extent do the threads, or mycelium, penetrate the bread? Put a piece of white cloth over the upper end of your lead pencil and rub over the black balls. What happens? What is the black dust on the cloth?

Growth of Mold.

Experiments. 1. Moisten a piece of bread and with a small splinter or the end of a match transfer some

of the dust or spores to the bread. Plant them in rows. Turn a tumbler over the bread and keep in a warm, dark place. Examine every day. How soon do you find mold growing from the spores? How long before spore cases, the black balls, appear?

2. Moisten a piece of bread. Collect some dust from furniture or corners of the room. Place this in rows on the bread. Cover with a tumbler and watch for results.

3. Moisten two pieces of bread and plant spores on them. Place one in a dark, warm place; the other in a warm, sunny window.

4. Get a moldy orange or lemon. What color are the spores? Rub a pin point over the spores and then insert the pin into a good orange. Sterilize another pin by passing it through a flame. Insert this in another part of the orange. Rub some of the spores on a small spot on the skin of the orange. Place the orange in a covered jar or dish so it will not be disturbed. Watch for results.

From your experiments answer these questions: What starts a growth of mold? What conditions aid the growth? What may be done to prevent mold?

Make a list of everything about the home that is likely to be affected with mold. How many different kinds of mold have you seen, judging from the color of the spores?

Discussion. Several different species of mold may be found about your home. One of the most common is bread mold, which has black spore cases and is sometimes called black mold. It produces a fluffy white mass of mycelium. Green mold is another common kind. The mycelium is composed of very fine white threads. You saw some of these around the pin in the orange before the green spores appeared. Sometimes you find on fruit a very white mold with a compact mass of threads and white spores.

The mold spores are so small that one by itself is not visible to the naked eye. They float about in the air and settle down upon food, furniture and clothing, forming a part of the dust. If they have moisture, something to feed upon, and the temperature is not too cold, they grow rapidly, producing first the mycelium and then the spores.

The spores may be killed by boiling water. You found also that they do not thrive in strong sunlight. Sterilizing cans, bread-jars, cake-boxes, etc., will prevent mold from growing.

Smuts. Look at a head of oats that has smut on it. Compare with a good head. Shake the smut-head gently over a sheet of white paper. What fall off? What other parts of the fungus must be present in the oats? How do you account for the fact that an oat plant with smut is shorter and smaller in every

way than a healthy plant? How does the smut get started on the oats?

Study a head of wheat that has smut on it just as you did the oats.

What parts of corn are affected by smut? To what extent does it destroy an ear? Break up a smutted ear and look for mycelium as well as for spores.

Discussion. A fungus like smut that grows upon living plants is called a *parasite.* All the smuts have mycelium that penetrate the stems of the plants and feed upon their juices. That is why smutted plants are always dwarfed. The dust that you find is, of course, spores. These are widely scattered in harvesting and threshing of the grain.

The life history of oat-smut is interesting. If you sow oat seeds that have smut spores on them, this is what happens: The spores germinate and grow soon after the oat plant begins its growth. The threads of the mycelium penetrate the young oat stem feeding upon its sap. As the oat plant grows the mycelium grows also, sending out many branches all through the stem. When the oats begin to head out, the mycelium grows into all parts of the head, and now it is ready to form its spores. Some of the mycelium threads penetrate the glumes (outer covering of the grain), and come to the outside to form their spore cases. Some form inside. Usually every grain or

what would have been a grain is filled with spores.

It is an easy matter to prevent oat-smut. The smut spores can be killed before the oats are planted. The following recipe is used by many farmers: Put one pint of forty per cent formaldehyde, sold under the name formalin, into thirty-six gallons of water. This is sufficient to treat forty bushels of oats. Put the oats into gunny-sacks, dip them into the solution, leaving them from ten to fifteen minutes. Then spread out on a floor to dry. Some farmers place the oats on a floor and sprinkle them with the solution, turning them over with a shovel so that every grain is moistened. Oat-smut often attacks fifteen per cent of the plants, which means a loss of fifteen per cent of the crop, often all of the profit on the crop.

The history of stinking smut on wheat is practically the same as that of oat-smut and it may be prevented in the same way.

Corn-smut spores live over winter in the soil of the fields or in piles of trash, especially stable manure, near the fields. In the spring some of them are blown around, alighting upon the young corn plant. Here they grow and produce spores which blow to other parts of the plant. Some of these attack the growing ears. To prevent corn-smut care must be taken not to leave in the fields material in which the spores can spend the winter. Another plan is to go through

the field, cut out the affected stalks, and burn them.

There are a number of other fungous diseases. Some of the most familiar ones are: 1. Potato-scab, which may be prevented by the same treatment as oat-smut. 2. Peach-rot, which attacks the half-ripe peach. This may be helped by burning all the dried-up peaches that are left on the trees and all the trash that collects under the trees. 3. Potato-blight, which may be prevented by spraying with Bordeaux mixture. 4. Tomato-blight should receive the same treatment as that of the potato. In both cases the spraying should be done early, before the blight has made any headway.

CHAPTER XV

YEAST AND BACTERIA

Material. Yeast-cakes either dry or compressed, sugar, salt, flour, several tumblers or wide mouth bottles.

Experiments. What is yeast? Examine a yeast-cake either dry or compressed. Of what does it seem to be made? If you have a dry cake, break off a piece about one inch square and crumble it into 2½ tablespoonsful of warm water at about 80° F. Do not have it too warm. Number six tumblers, wide mouth bottles or test tubes.

(a) Into numbers 1, 2 and 3 place ½ teaspoonful of flour and ¼ teaspoonful each of sugar and salt. Mix them together and stir in two tablespoonsful of warm water. Into this mixture stir one teaspoonful of the dissolved yeast or a small piece of compressed yeast.

(b) Into number 4 put the same ingredients as in 1 and 2 but omit the salt.

(c) In number 5 omit the sugar.

(d) In number 6 use nothing but water and the yeast solution.

Place tumblers numbered 1, 4, 5 and 6 in a warm temperature, between 80 or 90° F., and allow them to stand several hours or over night.

Place number 2 in a cool temperature, a refrigerator, or in a pan of very cold water and set out-of-doors.

Heat number 3 to a high temperature by putting it in a pan of boiling water, or steaming in a double boiler for half an hour.

After a number of hours carefully compare the different liquids, describe what you find and state any conclusions you may derive. How does number 1 differ from number 2? From number 3? In which has the greater change taken place, in number 4 or 5? Why do you think number 6 shows less change than the others which were in the warm temperature?

Make a list of the conditions that brought about the most noticeable results.

Making bread. Mix enough flour with the liquid of number 1 to make a stiff batter and allow it to stand in a warm temperature for an hour or two. What change takes place? Now put in a half cup of warm water and enough flour to make a stiff dough. When thoroughly kneaded place it in a glass. Measure the height to which it rises. Set in a warm place and in an hour measure it again. How do you account for the difference? If you wish to complete

the bread making process, knead the dough again, place it in a patty pan and let it rise once more. Then bake it in a hot oven. How do you account for the pores or holes that you find in the bread?

Explanation. Your experiments show that there is something in the yeast cakes that is affected by outside conditions. You found that the liquids in tumblers numbers 1, 4 and 5 were cloudy or turbid, while in numbers 2 and 3 the solid material had settled to the bottom and the liquid was clear. This shows that something took place in the warm temperature that did not occur in the very cold or hot temperatures.

Number 6 shows that the materials put into the solution with the yeast influenced the changes that took place.

While the compressed yeast-cake looked like a mass of frothy starch and the dry one like a mass of corn-meal and starch, each contained great numbers of tiny plants known as yeast. A single yeast plant is so small that you cannot see it without the use of a powerful microscope. In fact, you would have to place about 2,800 of them side by side to reach an inch in length. One yeast plant is an oval, colorless cell. See Fig. 48.

In a dry yeast cake there are a great number of these tiny plants alive but not growing. They are

said to be in a resting stage. In the compressed yeast the small plants are more active than in the dry yeast. When you place the plants in the proper conditions they at once begin to grow. These conditions are moisture, food, and a warm temperature from 70° to 90° F.

The food that yeast plants live upon is some form of sugar, fruit juices that contain sugar, or starch that is converted into sugar. Flour contains sugar.

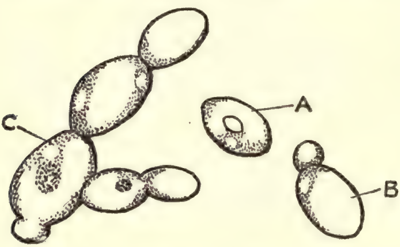

Fig. 48. Yeast plants. A, A single plant; B, A plant from which a bud is beginning to grow; C, A chain of plants showing how they grow by budding.

The small yeast plant when it begins to grow multiplies rapidly by a process known as budding. On the side of the cell a small swelling, called a bud, appears. This grows larger until it is about the size of the original cell and similar in appearance. Then a second bud appears, sometimes on the first cell, sometimes on the second, then another and another till there is a chain of cells making an irregular mass. Fig. 48.

As the plants feed upon the sugar they change it into two new substances, alcohol and carbon dioxide, CO_2. The bubbles that you found in the liquid and batter were CO_2. It is this gas that collects in bub-

bles throughout the dough and makes it swell or rise. When you put the bread into the hot oven the CO_2 expands with the heat and gradually passes out into the air leaving the bread very light and porous. The alcohol also changes to vapor and passes into the air.

Number 2 did not show any growth of yeast because the temperature was too low for the growth to take place. Heating number 3 killed the yeast plants so there was no growth. Number 6 did not grow because of lack of food.

BACTERIA.

Material. Some fresh milk; a small piece of fresh lean beef; a potato; a few small vials; several tumblers and wide mouth bottles or test tubes; a double boiler or kettle; a package of sterilized cotton.

Experiment. To determine why milk sours. 1. Place one of the wide mouth bottles on its side in a kettle of warm water and heat the water to the boiling point. With a fork turn the bottle over and over in the water for about ten minutes. Take it out and stand it inverted on a clean table until it cools. Fill it half full of fresh milk, close the top with cotton and set it aside in the schoolroom, or in the kitchen if the experiment is tried at home.

2. Into another bottle place a small amount of dust gathered from some place about the room. Fill

the bottle half full of milk and stand it beside bottle number 1.

3. Wash two bottles, fill each half full of milk, plug with cotton. (a) Place one in a warm temperature, near the stove or register. (b) Put the other in a very cool place. If you have no refrigerator, place it in a pan of very cold water and set the pan out-of-doors on the north side of the house.

4. Sterilize a bottle as in experiment 1. Fill it half full of fresh milk and stir into it a half teaspoonful of very sour milk. Place it beside bottles numbers 1 and 2.

5. Sterilize a bottle as in number 1. Fill it half full of milk and set it in a double boiler. Keep the water boiling for about twenty minutes. Remove the bottle and cool it as quickly as possible. Plug with cotton and place with numbers 1 and 2.

At the expiration of ten or twelve hours examine the milk in all the bottles to determine whether or not any changes have taken place. Examine again after twenty-four hours or when definite changes have occurred. In which bottle does the milk sour first? In which does it remain sweet longest? What is the effect of sterilization? Of a warm temperature? A cool temperature? Why does milk sour?

Keep bottles number 2 and (a) of Experiment 3 in a warm place for a number of days. Does the odor or

color indicate that anything besides souring is taking place?

Explanation. The souring of milk is due to small one-celled plants called bacteria. If you wish to speak about one of them you call it a bacterium. They are very much smaller than yeast plants. Like yeast, however, they grow and multiply very rapidly when proper conditions are present. They multiply by cell division; that is, one cell divides into two. These grow and in a short time each divides again. This continues until in a few hours there may be thousands of new cells from the one individual.

Your experiments have enabled you to determine for yourself what the proper conditions for growth are. You found that the milk in the cool temperature kept sweet much longer than that in the warm place. Bacteria grow and multiply rapidly in a warm temperature. They feed upon the sugar in the milk changing it into an acid. Bacteria that sour milk are not harmful to man. Sour milk is a wholesome food; but usually we wish to keep milk sweet for certain purposes, and for that reason we keep it cool to prevent the bacteria from growing. By using care with the utensils in which milk is kept we may reduce the number of bacteria. Have you thought out why the milk in bottles numbers 2 and 4 soured so quickly, while that in numbers 1 and 5 remained sweet so

long? By keeping number 1 in the boiling water you killed all the bacteria that it contained, while in number 2 you increased the number of bacteria by putting in the dust. In number 4 there were a great number of bacteria in the sour milk. By heating the milk in number 5 you killed most of the bacteria.

Your experiments then lead to the following conclusions:

1. Bacteria cause milk to sour.

2. The more bacteria there are present, the more quickly milk sours.

3. Sterilizing the vessels in which milk is kept aids in keeping it sweet.

4. A cool temperature retards the development of the bacteria and keeps milk sweet longer.

5. Heating milk for a period of twenty or thirty minutes kills most of the bacteria that it contains, hence it remains sweet for a long period.

6. The bad odor of the milk in bottles numbers 2 and 3 (a) tells you that there were other bacteria in this milk than those which caused it to sour. They caused the milk to spoil or putrefy, and milk in this condition is not only unwholesome but dangerous. If you heat milk for two or three minutes you may kill most of the bacteria that cause sourness, but leave unharmed the ones that cause putrefaction. The milk in this case may remain sweet for several days and

yet be unwholesome. To insure the death of all bacteria the milk should be heated to a temperature of 145° F. to 167° F. and kept at this temperature about half an hour. This is called pasteurizing milk. Sterilized milk is heated to the boiling point, allowed to cool, then heated again to the same temperature.

Some experiments with meat.

1. Cut a piece of fresh, lean beef into small bits and put them into one of the test tubes or bottles. Pour boiling water over them and then steam in a double boiler for an hour. Plug the test tube with cotton, cool as quickly as possible and set aside.

2. Put about the same number of pieces into another bottle. Pour cold water over them. Leave the bottle open and stand it beside number 1.

3. (a) Put a piece of the beef into another bottle and place in a refrigerator or in any cool place. (b) Put another piece into a bottle and leave in a warm temperature.

Look at all of the bottles every day noting the changes that take place. Which first shows evidence of spoiling? Which keeps in a good condition longest? What conclusions do you come to as to why meat spoils?

Explanation. From your study of milk you have probably concluded the beef spoils because of bacteria. Boiling kills the bacteria; thus the beef in

bottle number 1 kept in a good condition longer than that in number 2. The piece of beef that was placed in number 3 (b) without moisture kept fresh longer than number 2 because bacteria must have moisture in order to grow and develop. While there is some moisture in the meat itself the greater amount in number 2 made rapid growth possible. Number 3 (a) simply shows that the bacteria develop more slowly in a cool temperature.

Some experiments with potatoes. Wash a potato and boil until it is cooked through. Sterilize a knife by holding it in a flame or boiling water a few minutes. (a) Cool the potato, then cut off a slice about half an inch thick, place on a saucer, turn a tumbler over it, and place in a dark part of the room. (b) Cut another slice and over this scatter a little dust collected from the room. Cover this also with a tumbler and place beside the first specimen. (c) Cut another slice and let some one who has dirty fingers press them into the potato; treat as in (a) and (b). (d) Prepare another slice exactly like (b), but after covering with the tumbler set in a sunny window. (e) On another slice put some dust as in (b), then sprinkle with water in which you have put a few drops of formalin. Set beside (b).

Look at the specimens every day keeping a record of what happens.

Explanation. You may find several different things taking place on the potatoes. Some may have bright red or yellow spots. These are masses of certain kinds of bacteria that are growing and feeding upon the potato. You may find that on some a growth of mold has started. The greater and more rapid growth on the potato of experiments (b) and (c) shows that dust contains bacteria. The failure of the bacteria to grow on the potato in the window and on the one with formalin proves that sunlight is a real enemy of bacteria and that formalin kills them.

From your experiments and the explanation you have learned something about a few of the bacteria that are found around your home and school. There are, however, many other kinds that you will learn more about in high school and college. Just how many different species of bacteria there are nobody knows, but we do know that these little organisms are abundant everywhere. They are in the air, the water, the soil, in the dust that settles upon furniture and other objects in the home, and in certain kinds of food, notably butter, cheese and vinegar.

Most bacteria are perfectly harmless; some are real friends. Among the most beneficial are those that work in soil changing into soluble form the compounds found there both in the broken-up rock and in the humus so that they may be dissolved in the water

and taken into the root hairs. Other kinds of bacteria that we must consider our friends are those that cause decay of all kinds of dead plants and animals.

Bacteria are of three different forms: 1. Cocci, which are spherical; 2. Bacilli, which are rod-like in shape; 3. Spirilla, which are in the form of a spiral.

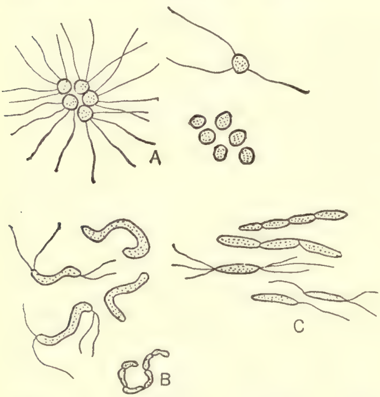

Fig. 49. A group of various kinds of bacteria. A, Coccus forms; B, Spirillum forms; C, Bacillus forms.

Bacteria and health. Some bacteria are deadly enemies because they cause some of our most dangerous diseases, chief among which are tuberculosis, typhoid, diphtheria, dysentery, pneumonia, grippe, and colds.

We often speak of bacteria that cause these diseases as germs. When these germs are taken into the human body they may in a short time begin to grow and multiply. In the process of growth they produce poisons known as toxins. It is these poisons that cause fever and sickness. An important point to remember is that none of these diseases start unless the germs are in some way transmitted from a person who is ill to one who is well. If people who have these diseases

were careful not to allow any of the germs to be carried from the sick room and distributed to other people, all infectious and contagious diseases could within a few years be exterminated.

Quarantine and disinfectants are means taken to prevent the spread of diseases. As soon as the health officer in any community knows of a case of a contagious or infectious disease, and it should be reported to him by the physician as soon as discovered, he at once puts up a placard with the name of the disease. This is the signal for everyone except the nurse and physician to stay out. People who are quarantined should realize that while it is a misfortune it is no disgrace. They should do everything in their power to keep the quarantine.

Disinfectants are substances that are used to kill bacteria that may escape from the sick room and infect other people. Carbolic acid is one. This should be made into a weak solution, which means about three and one-half ounces of carbolic acid to a gallon of water, or four teaspoonfuls to a pint. Clothes and vessels used in a sick room should be washed with this solution. The burning of sulphur candles in a room is a fairly good disinfectant for most disease germs. Of course, sulphur must be burned when there is no one in the room, since human beings are poisoned by the fumes. Formaldehyde is now used most

commonly in disinfecting buildings or rooms. Special directions are necessary if this work is done properly. In many places school buildings are disinfected at least once a month. Can you explain why?

Besides the use of disinfectants there are other ways to prevent the spread of disease bacteria. One is cleanliness; keeping the air we breathe and the food we eat free from disease germs. This means care in the home and school. It means as little dust as possible, the use of vacuum cleaners, of dustless dusters, of rugs instead of carpets; in fact, everything that keeps dust out of the air. Water heated to the boiling point kills many germs. This should be used freely in washing dishes and clothing.

One of your experiments suggests another method of combating bacteria, that is by sunlight. Few kinds of bacteria can live in the light of the sun. Clothing and bedding should be exposed to the sun and air occasionally to kill any germs that may be hiding in them, and to keep them in a sanitary condition.

Fighting bacteria with good health. After all, one of the strongest weapons with which to combat disease germs is good health and germ resisting power. When germs are taken into the body the white corpuscles of the blood at once begin to destroy them. If the corpuscles are numerous and the blood in good condition, the corpuscles are likely to come off victor-

ious in their struggle with the germs. The corpuscles are aided in this work by another substance in the blood known as the germicidal substance. This attacks the germs killing them before they can produce enough toxin to cause sickness. The blood also produces an anti-toxin which helps to destroy the toxin. Now if your body is in a healthy condition all of these agents work together and the result is that the bacteria are destroyed without your having any evidence of their presence in your body, or, if they succeed in causing illness, the attack is likely to be a mild one.

Certain diseases are treated by putting into the blood some of the anti-toxin of the disease so the blood will set about making more of the germicidal substance and thus always have enough to prevent the disease from getting a hold in the body. Typhoid fever, diphtheria and smallpox are satisfactorily treated in this manner.

People are not likely to take certain diseases such as smallpox and measles a second time. This is because the disease leaves enough of the germicidal substance in the blood to kill off any germs of the disease that may attack the body later.

Here are some simple rules to follow in combating bacteria that cause human diseases:

1. Keep all rooms, especially sleeping rooms, well ventilated.

2. Keep window shades up to allow the sunlight to enter rooms freely.

3. Avoid stirring up dust in living rooms, and remove with an oiled or damp cloth any dust that settles upon furniture and other objects.

4. Keep the body clean and pay particular attention to the hands and nails.

5. Do not form the habit of spitting in the street, but help all you can to enforce ordinances against spitting in public places.

6. Do not eat fruit that has been exposed to the dust of the street without washing thoroughly.

7. In case of a typhoid fever epidemic boil drinking water.

8. Keep up a constant warfare against flies and mosquitoes till they are exterminated from your community.

9. Keep your body in good health by following the proper rules of eating, exercising, sleeping, and avoiding stimulants such as tobacco and alcohol.

10. When you sneeze or cough be sure to cover your nose and mouth with your handkerchief. This precaution will keep your disease germs from spreading to other people.

CHAPTER XVI

PROPAGATING PLANTS BY CUTTINGS

Material. Geraniums, coleus, lantana, wandering Jew, heliotrope, or any other plants that may be started from cuttings or slips; a sharp knife; a propagating box and flower pots.

While many of our garden plants, both flowers and vegetables, are grown from seeds, some are propagated in other ways. Some familiar examples are the growing of onions from bulbs, of potatoes from tubers, of strawberries from runners. Make a list of all the different methods of propagating plants that you know with an example of each.

The propagating box. One of the first things to do if you are planning to make cuttings is to prepare a box in which to grow them. Any wooden box will serve. If you grow them in the schoolroom or at home, you will have better success if you make one side of the box about two inches lower than the other so that it will have a sloping top. Nail a narrow strip of wood just inside the box all the way around so you may place a pane of glass over it. Fill the box about two-thirds full of clean sand or

other soil, moisten thoroughly, and the box is ready for the cuttings.

You may make a box that will serve as a window-box as well as for propagation. This should be made the right length to fit the window in which you wish to place it. It should be about eight inches deep and from six to eight inches wide. Any kind of lumber will serve, but cypress is the best since it stands moisture better than other woods. Bore two or three holes in the bottom for drainage and put in first a layer of coarse material, cinders or pebbles, then put in the soil. If the soil is rich, heavy, black loam, a small amount of sand mixed with it will be an advantage. If it is not very rich, humus, either leaf mold or well rotted stable manure, will improve it. A good soil mixture for potting or for window-boxes is one-half loam, one-fourth sand and one-fourth humus.

Soft Wood Cuttings

Cuttings. A common method employed in growing certain plants is by the use of cuttings. You may use different parts of plants to make cuttings. Some begonias are propagated by leaf cuttings. You make tuber cuttings when you plant potatoes. Most cuttings, however, are made from stems.

There are two kinds of stem cuttings, the soft or

green wood, and the hardwood. A number of plants grown in the garden and in the home are propagated by softwood cuttings. Some of the best ones to use for this purpose are coleus, sometimes called foliage plants, salvia, geraniums, lantana, balsam, heliotrope, tradescantia or wandering Jew.

Choose a fresh, thrifty looking branch of coleus or other plant for your cutting. Look at it a mo

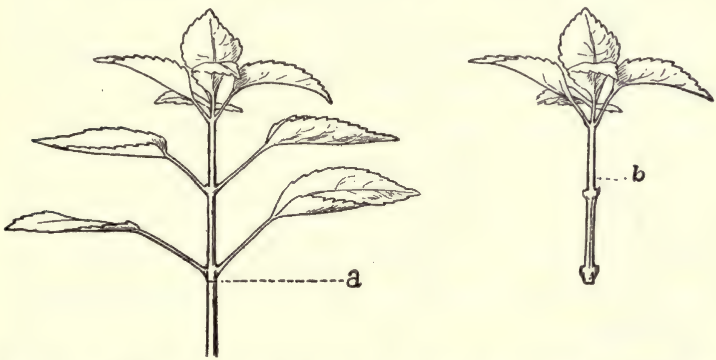

Fig. 50. a, Where the cut is made; b, How the cutting should look when finished.

ment to determine how the leaves are arranged. We call the place on the stem from which the leaves grow a node. Use a sharp knife and make a clean horizontal cut just below a node. (Fig. 50a shows how this is done.)

Cut off the lower leaves and trim the ends from the upper ones. Why is this done? You know that leaves of plants constantly give out moisture. By

thus reducing the leaf surface the cutting will not lose so much moisture. Fig. 50b shows how the cutting should look when finished.

With a wooden paddle or sharpened stick make a drill in the sand or soil of your propagation box. Place the cuttings in the drill about two inches apart. With your fingers firm the moist soil closely around them. Water the plants thoroughly and keep in a dim light for two or three days. You may accomplish this by covering the box with a newspaper. After two or three days give the plants plenty of light and water when needed. They should from the beginning be kept in a warm temperature. They need air as well as light and water, so if you are growing them in a glass covered box be sure to raise the cover a few minutes every day for the purpose of ventilation.

There is another way in which cuttings may be grown that is very satisfactory for either school or home. Place the usual pebbles or coarse materials for drainage in the bottom of a large flower pot eight or ten inches in diameter, and fill with soil leaving a space in the middle. Plug up the hole of a small pot three or four inches in diameter and set this inside the large one. Fill the space between pots with soil and place the cuttings here. Keep the small pot filled with water. Coleus plants may not only be

started in this way but they may be kept all winter making a very pretty mass of foliage.

The callus and roots. What do you expect your cuttings to do in the propagation box? The very best way to answer this is to wait three or four weeks until the cuttings are ready to be transplanted. Then take one up and examine the cut surface. What has taken place? The rounded portion at the end of the stem where the cut has healed is called a callus. The first thing the cutting does is to form a callus by laying down a new layer of cells over the cut surface. After this it sends out roots. If a callus does not form the cutting dies. Where have the roots appeared? Compare different cuttings to determine whether they sent out their roots with equal rapidity.

Transplanting. Now that the roots have developed your cutting is ready to transplant. You may transplant it into a window-box or flower pot. If you have no pots, tin cans will serve equally well. Punch a few holes in the bottom for drainage. Place a few pebbles or bits of broken pottery in the bottom of the pot or can. Then fill it half full of soil using the mixture suggested above. Place the cutting in the center taking care to spread out the roots. Hold it in place with your left hand while with your right hand you fill the space around it with soil, firming it closely about the plant. Do not fill the pot to the

brim. Leave a space of at least three-fourths of an inch. Water thoroughly and leave in a dim light for two or three days.

Caring for the plants. After the plants are well started, place them in a warm, well-lighted window; a south window is best but they will do fairly well with care in other windows.

The chief points to consider in caring for your plants are: First, to see that they have the right amount of water. It is better to give them a thorough drenching two or three times a week rather than a little sprinkle every day. When the soil looks dry on top it is time to water. The temperature of the water should not be lower than that of the room in which the plants are kept. Besides water plants need fresh air. This is easily supplied. Air that is fresh enough for you to thrive in is all right for your plants. You should be careful, however, when the weather is severe not to allow cold air from an open door or window to strike them. During the very cold weather ventilate from another room.

Plants also need certain mineral foods that are obtained from the soil. If soil is well supplied with humus, it is probably rich enough. If not, a fertilizer may be used. The following recipe is recommended by gardeners: Procure three ounces of nitrate of soda, one ounce phosphate of soda, and two ounces

of sulphur of potash. Pulverize and mix these materials thoroughly. When required for use put a level tablespoonful into a gallon of hot water. When cold use about a teacup full for pots five and six inches in diameter and more or less in proportion to the size of the pots. Do not apply oftener than once in two weeks. Be careful not to allow the nitrate to touch the foliage.

Value of cuttings. Why is it an advantage to propagate plants by cuttings instead of seeds? One advantage is that you get results much sooner. The most important advantage, however, is that when you use a cutting you are perfectly sure to get the particular variety of plant from which the cutting is made. You cannot always be certain of the exact variety when seeds are used. In many cases seeds do not hold true to variety.

Softwood cuttings may be made at any season. House plants that have done well over winter may be used to make cuttings in the early spring to transplant later to the yard or garden. Late summer is a good time to make cuttings for winter blooming.

Hard Wood Cuttings

Material. Twigs or small branches from grapevines and shrubs of various kinds.

Hardwood cuttings of shrubs or trees must be made late in the fall or winter when the plants have stopped their work and are inactive. They are sometimes called dormant cuttings because they are made when the plants are in a dormant or resting condition.

You may propagate grapes, currants and gooseberries, as well as almost all of our ornamental shrubs, by means of cuttings.

Grape cuttings. If you have access to a grapevine, go out and examine it. Find the stems that have grown this season. How long are they? Take some actual measurements. How do they differ from the older portions of the stem? Find where the leaves were attached. Where are the tendrils in relation to the leaf scars? Do grapevines depend wholly upon tendrils for climbing? Describe the buds. Are they opposite or alternate in arrangement? Where is the bud situated with reference to the leaf scar?

Make the grape cutting from this season's growth. Use care in making the cut. Place your knife on the side of the stem opposite a bud and on a level with the top of it. Now make a slanting cut downward so that the knife will come out just below the bud. You have thus made an oblique cut directly through a node. Each cutting should have at least three good buds. When you have made a number, tie them together into a bundle. Nurserymen tie them in

fifties and hundreds. Place them in a box of moist sand or soil taking care that the lower end is well covered with sand. Put the box in a cellar or other cool place. It may be set out-of-doors and covered with straw or sand. If the box is kept in the cellar, look at it occasionally during the winter to see that the sand does not dry out.

Shrub cuttings. If you should like to have shrubs on your home or school grounds and are willing to wait a year or two, you can easily start them by the use of cuttings. The following are easily propagated in this way and are excellent shrubs for the home grounds: Japanese barberry, common barberry, all the bush honeysuckles, snowballs, high bush cranberry, hydrangeas, snowberry, and all the spireas.

Frequently in parks and home grounds these shrubs are pruned during the early winter. Ask the owner for some of the fresh branches and use them to make cuttings. If no pruning is in progress, ask some one who owns large shrubs to let you have a few young branches. They may be taken from the thickest parts without being missed. Use the same plan that is suggested for grape cuttings. You will find that some of the shrubs have many nodes and therefore the buds are very close together, so in order to have your cutting six or eight inches long it may have a large number of buds. In that case it is a good thing to

cut off the lower buds leaving two or three at the top. Tie the shrub cuttings together and place them as you did the grape cuttings in a cool, moist place for the winter.

What do you expect your cuttings to do during the winter? You must wait until spring to be sure of the answer. Then if you look at your cuttings, you will find that they have made a callus around the margin of the cut. Probably some of them will have already sent out roots.

Setting out the cuttings. Just as soon as the ground in your garden can be worked in the spring set out your cuttings. Dig a trench deep enough so that when the cuttings are placed in it only the topmost bud of each will stand above the surface of the soil. Place them from eight to nine inches apart and firm the soil well around them. During the summer they should be kept free from weeds and cultivated carefully. If the season is a very dry one and they begin to show signs of wilting, they should be watered.

The second spring or fall they will be ready to transplant to their permanent places on your home ground.

CHAPTER XVII

FRUIT AND FRUIT TREES

Material. Fruit trees of the neighborhood; twigs of apple and other trees; fruit of apple, pear, orange and others.

Study. Make a list of fruit trees that grow in your community. For what purpose are they grown? Which species is most abundant? Which next? What fruits are on the market that do not grow in your neighborhood? What fruit trees do you consider most important the world over?

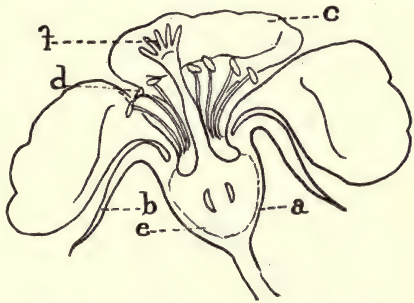

Fig. 51. Section of an apple flower: a, Receptacle; b, One of the sepals; c, One petal; d, Stamens; f, Upper part of pistil; e, Ovary, the lower part of the pistil.

The apple. Examine an apple. What parts do you find? What is the use of the skin? To answer this remove the skin from an apple and then allow the apple to stand on the table for several days. Why is a thick skin of value when apples are to be shipped

or kept a long time? Compare the skin of early and late apples. Notice the shape of the apple where the stem is attached. The hollow space around the stem is called the cavity. Examine the opposite end and describe what you see. The hollow portion here is the basin. What do you find in the center of the basin? What is this the remains of?

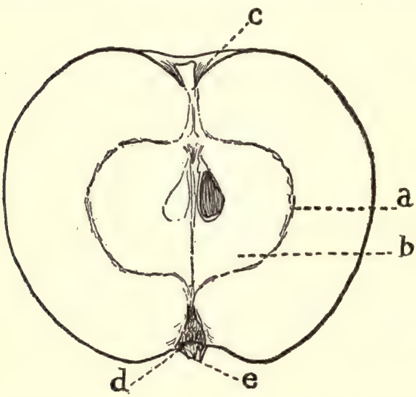

Fig. 52. Section of an apple showing parts: a, Core line; b, Core with seed cell and seed; c, Cavity; d, Basin; e, Remains of calyx.

Cut an apple crosswise through the middle. How many distinct structures do you find? What is the shape of the core? How many cells has it? How many seeds in a cell? Look for the core line which connects the points of the star. Cut another apple lengthwise and look for the same structures. Trace the core line from the cavity to the basin. In which direction do the seeds point? What parts of the flower produce each part of the fruit? Study Fig. 51.

An apple shows something of all parts of the flower except the corolla. The stem of the apple is the stem of the flower grown somewhat larger. In the basin

are the dry remains of the sepals and often a few of the withered stamens and styles. The core is the ripened ovary with its five pointed cells which contain the seeds. Around the core is the receptacle which has become thick and juicy and constitutes the part of the apple that is eaten.

History. There is no question that the apple is the most important of all fruits. It is probably a native of southwestern Asia. It has been cultivated from time immemorial, probably long before the beginning of written history. It is now grown in all countries situated in temperate zones. While there is but one species known as *Pyrus malus,* there are hundreds of varieties, some of which are adapted to one kind of soil and climate, others to different conditions.

Discussion. The apple tree does not grow very tall but spreads out making a round crown. On young trees the bark is quite smooth and the tree rather symmetrical. After it reaches middle age, that is, when it is from twenty to forty years of age, its branches lengthen very slightly each year, the bark becomes rough and shaggy, and the whole tree has a gnarled appearance that makes it very picturesque.

Varieties of apples. Bring in for study specimens of different varieties of apples. Compare them as to shape, size and color. Compare two apples of the same variety grown in different parts of the commu-

nity. Group the apples into winter and fall varieties. There are probably no summer apples left at this time. What is the most striking difference between the two groups? The fall apples are more mellow; they are almost ripe. Winter apples are mature but will ripen later in the season. Apples are mature when the seeds are brown, but they are not ripe till the pulp is soft, mellow and juicy.

Make lists of different varieties of apples, grouping them according to the time they mature, as—Summer apples: duchess, harvest, early June, yellow transparent. Fall apples: Grime's golden, snow, Jonathan, maiden blush, bellflower, wealthy. Winter apples: northern spy, wine sap, gano, russet, willow twig, salome, wolf river, stark, Ben Davis, baldwin, greening, spitzbergen, Jeannet, pippin.

Picking, storing and marketing. Discuss methods of picking and storing apples. The main rule to follow in picking apples is not to bruise them or break the skin. This means that they must be hand-picked, not shaken from the tree. Determine whether all the apples on one tree are equally large, well-shaped, and brightly colored. Look for any that are imperfect. Apples with warty knots have been affected with a fungous disease.

Grade your apples by placing together the finest, the next best, and so on. Firms who make a spe-

cialty of selling apples have several grades. One large city firm grades as follows: Extra fancy, in which all the apples are perfect; Fancy, in which they are nearly perfect; Choice, good fruit but not all well-colored; Number two, fruit that is hand-picked but varies in size and color; however, no apple less than two and one-half inches in diameter is considered. Any apple smaller or less perfect than Number two is called a cull.

In preparing apples for market some are packed in barrels, others in boxes. When apples are properly packed they lie in layers and there are no large spaces left vacant. The apples fit close, but not close enough to bruise each other. Fancy apples from western orchards are often wrapped singly in tissue paper just as oranges are.

In keeping apples in your home over winter three conditions are essential: First, temperature; the apples should be kept as cool as possible. A temperature of from 36° to 40° is considered good. Second, ventilation; they should be placed in a room where there is plenty of fresh air. Third, moisture; if the air is dry the apples will lose their freshness by evaporation. In a fruit cellar with windows all of these conditions are easily secured. Summer and early fall apples may be canned or dried for future use.

Uses and distribution of apples. Make a list of all the different ways that apples may be cooked and served as food. Consult your geography for the apple growing regions of the country. How important is the apple growing industry in your own state?

Other fruits. Make a comparative study of other fruits noting resemblances and differences. Which ones are similar in structure to the apple? Which differ most widely?

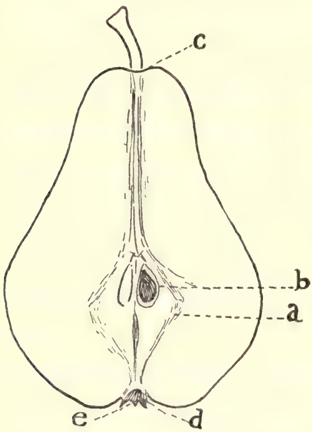

Fig. 53. Section of a pear: a, Core line; b, Seed cell and seed; c, Cavity; d, Basin; e, The withered remains of the sepals or calyx.

The apple, quince, pear and crabs resemble each other in structure. Each has the core formed from the ovary and the thickened receptacle which forms the chief part of the fruit. This kind of fruit is called a pome.

The fruit of the peach, plum, cherry and apricot is known as a drupe or stone fruit. In this the inner wall of the ovary hardens into a nutlike covering which encloses the seed. The outside layer thickens making the fleshy part that is used for food. The orange is a type of berry with a thick, leathery skin.

This tough covering is a great advantage to growers of oranges since it is possible to ship the fruit long distances. It is also such a perfect protection against bacteria and mold spores that the fruit keeps in good condition many weeks with little care. The skin of apples and of other fruits is a protection against germs that cause decay. It also prevents the rapid evaporation of the juices.

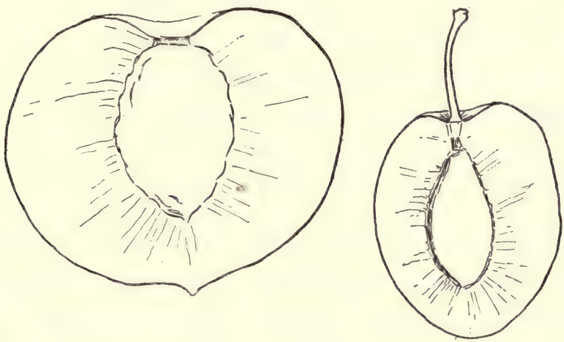

Fig. 54. Section of a peach, a type of drupe or stone fruit. A plum, showing resemblance to peach.

The peach. The peach, too, is a native of central or south Asia, probably of Persia. The scientific name is *Persica.* Peaches are not grown as universally as apples, being less hardy. They require a rather warm temperature. In most cold regions the trees die during the winter, and even in regions where the trees survive severe winters the fruit or flower buds are frequently killed, so that in many places

a crop of peaches is produced only once in two or three years. The most northerly peach growing centers, Michigan, Maryland and Long Island, have their climate tempered by nearness to large bodies of water. Peaches are grown extensively in warm climates, in some parts of Georgia and Texas and in other southern states, as well as on the Pacific coast. There are two chief groups of peaches, those with white pulp and those with yellow. Some of the common varieties are—Yellow: Elberta, Crawford, Hale, gold drop, Sincols and Fitzgerald. White: Champion, Carmen, Greensborough, and Belle.

Fruit trees. Make a special study of your apple orchards and other fruit trees. Find out if you can how old the orchard is. Look carefully at the trees. Are any of them broken? Are there any dead branches or suckers? Select one tree for special observation. How tall is it? You may estimate the height of the tree by measuring your own height upon the trunk, then estimating about the number of times the tree is taller than you. How thick is the trunk? What is the color of the bark? Is it rough or smooth? What is the shape of the tree? Compare young and old trees in regard to appearance. If there are apples on the tree notice on what part of the branches they are borne and how they are attached to the twigs.

Twigs. Look closely at a twig and make a list of everything that you find. How do the new and old parts differ? Where are the buds situated? How many different kinds of buds are present? Determine if possible which ones will produce the leaves and which the flowers in the spring.

Compare the twigs of other fruit trees. On which do you find bud clusters? How many in one cluster on the peach? Plum? Cherry?

You find the twigs of the apple tree covered with whitish fuzz with buds along the sides and at the ends. These are all leaf buds. Here and there you find a short spur-like twig with a bud at the end. That is the flower bud that will produce the fruit next year. If you have looked carefully at your apple trees you find all the apples attached to spurs.

Propagation. How are apple, peach and all other fruit trees propagated? Most people who have orchards or fruit gardens buy young trees from a nursery and transplant them. In most cases this is probably the wisest thing to do. But if you are willing to wait three or four years longer for your apples and pears and two years for peaches, cherries and plums, you can raise your trees from the beginning.

Seeds and seedlings. To raise an apple tree the first thing to do is to plant seeds. Any apple seeds

will do, but most nursery men use those of a hardy, wild apple found growing on the hillsides in certain parts of France.

Plant the seeds in drills in the fall or early spring. If planted in the spring moisten them and leave them out over night that the frost may aid in breaking the hard covering. When the seedlings come up, thin them till they stand about three inches apart in the row. Cultivate during the summer as you would any garden plant. In the fall remove them from the ground, cut off the stems leaving about eight or nine inches attached to the roots. Tie them in bundles and place in moist sand or moss in a cool cellar.

Grafting. If the seeds you planted were from a Jonathan or any other special variety of apple and you allowed the seedlings to grow until they were old enough to bear fruit, the apples probably would not be Jonathans or any other variety that you planted. They might be very good, but the probability is that they would be small, sour, inferior apples. In order to obtain any desired variety grafting is necessary. If you wish a Jonathan apple you must graft on to the root of your seedling a stem or bud taken from a Jonathan tree. The same is true, of course, of any other variety that you desire.

The root or part on which the graft is placed is

called the stock. The part that is grafted on is called the scion. It is very essential to choose the scion from a tree that bears well and that has excellent fruit, for your grafted tree will inherit all the qualities of the tree from which the graft is taken. You may graft at any time during the winter or very early spring. Nurserymen do most of their grafting in January and February.

To make the graft, first cut the stems from the seedling and trim all the branches from the root. Now make a long diagonal cut near the upper part of the root; this is your stock. Choose a scion of about the same size. Make the same kind of cut. Now make a slit on the cut surface of each and slip them firmly together. See Fig. 55.

Use great care to see that the layer directly under the bark of the scion meets the same layer of the stock. This is essential because this layer, called the cambium, is where new growth occurs; hence this is the only place where stock and scion can grow together. The next step is to wrap grafting thread or raffia firmly around the graft. Some nurserymen cover the wound with grafting wax. When you have made a number of grafts tie them together and return them to the moist sand in the cellar. Leave them until the soil is in good condition to work in the spring, then set them out in rows nine or ten

inches apart and deep enough so that two or three inches of the scion will be above the ground. The scion grows fast to the stock and then grows upward producing the little apple tree, while the root is all that is left of the seedling.

When the little tree is well started it is a good thing to remove some of the buds allowing only the

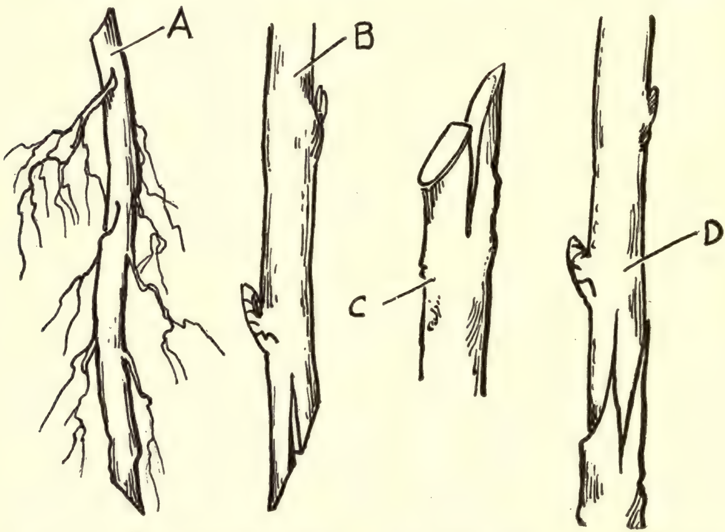

Fig. 55. Root tongue-grafting. A, The untrimmed root of the seedling; B, Scion trimmed and ready to be inserted; C, Enlarged section of A trimmed and slit ready to receive the scion; D, Scion inserted in stock.

stronger ones to produce the tree. Nurserymen leave the trees from two to three years in the nursery row, then they are ready to be removed and set out in

the orchard or fruit garden. The kind of grafting just described is known as root tongue-grafting.

In some apple growing regions apples are propagated by budding instead of grafting. Budding is really a form of grafting in which a bud of the desired variety is placed on the stock of the seedling. Pears and quinces are propagated just as apples are. Sometimes if seedlings are scarce nurserymen make three or four stocks from the same root, cutting it into lengths of three or four inches.

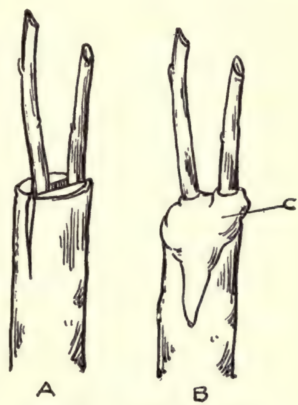

Fig. 56. Cleft grafting. A, The stock with two scions inserted; B, The same with grafting wax; C, In place.

Cleft grafting is used when one wishes to graft onto a young growing tree or a branch of an old tree. The stem is sawed off and is cleft or split across the center. The scion, which is a one-year old stem, is cut wedge-shaped a little thicker on one edge than the other. This is inserted into the cleft with the thicker edge outward, so that the cambium meets the same part of the stock. If the stock is more than an inch thick two scions are inserted, one in each side. The wounds are covered with grafting wax. By means of this kind of grafting

one may change an undesirable variety into one more desirable, or raise several different varieties of fruit on the same tree.

How long will it be after the tree is set out in the orchard before it will produce apples? Different kinds of apples vary in this respect. Some produce apples in six or eight years, others require ten to twelve years. You see, then, that to make an apple tree beginning with the seed requires one year before it is ready to graft, two or three years in the nursery row, and from six to ten years in the orchard before it bears fruit. How long will an apple tree continue to bear fruit? You have perhaps visited at your grandparents' farm where there is an orchard still bearing fruit that was set out when your grandfather was a young man. Apple trees, if well taken care of, will bear from twenty to fifty years.

Propagating a peach tree. You can easily propagate a peach tree of any desired variety. Plant the seeds in the fall covering them lightly so that freezing will break the hard shell. In the spring thin to about six inches. In the late summer or early fall bud the seedlings just where they stand in the nursery row. First take a one-year twig from the variety of peach that you wish to produce. Trim off the leaves leaving the petioles sticking out like little stubs. Nurserymen call this a "budding stick." In

the bark of the seedling make a T slit about two inches from the ground. In warm climates this is always made on the north side. Cut a bud from the stick with a slice of the bark and a little wood, and using the leaf petiole as a handle slip the bud into the T slit pushing it well down and covering it with the little flaps of bark at the top. Wrap with raffia or grafting thread. See Fig. 57. It is often well to place two or three buds in the same stock. If the bud does well it will grow fast to the stock at the cambium layer. In the spring cut off the top of

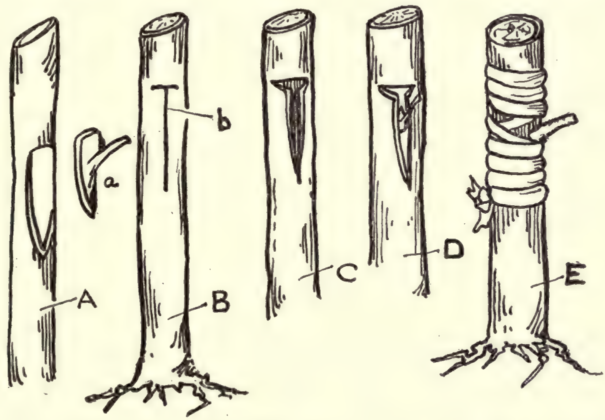

Fig. 57. Budding. A, Budding stick with one bud cut out, a; B, Seedling tree with "T" slit, b; C, Same as B showing flaps of bark folded back; D, Bud in place; E, Bud wrapped with cord or raffia.

the seedling and leave the strongest bud to grow and develop into your peach tree.

In the fall or the following spring the tree will

be ready to transplant. In three or four years it will bear fruit.

Orange trees also are propagated by budding. Seeds from the sour oranges or lemons are used for the stocks because they are hardier than those of the sweet oranges. Great care must be taken to plant the seeds as soon as they are removed from the fruit. If they are allowed to dry they will not germinate. They are planted in rows about two feet apart. After six months or a year they are transplanted to rows from three to four feet apart, the plants standing about ten inches apart. At the end of three or four years they are budded, usually in the fall. After a full season's growth they are set out in the orchard and in three years are beginning to bear fruit.

Cherries, plums and prunes are propagated by budding; pears and quinces by grafting or budding.

Care of Fruit Trees

Cultivation. How far apart are the cherry trees in your orchard or fruit garden? The pears? Peaches? Apples? Oranges? Lemons? What is the condition of the soil between the rows? Are other plants grown here? What do you find in old orchards? Young ones? Young orchards should be cultivated frequently for two reasons: 1. To keep down weeds. 2. To conserve the moisture.

Pruning. When are the fruit trees in your neighborhood pruned? Who does the work? What tools are used? Why is pruning necessary? Examine a pruned tree. Is each branch cut close to the stem or is a portion left as a stub? Watch the scar for a number of weeks to find out how it heals. What has the cambium to do with this? Examine an old scar.

There are at least three good reasons for pruning fruit trees: 1. To secure a well formed tree. This means proper pruning when the tree is young. 2. To remove superfluous branches or suckers so that the fruit bearing branches may get more nourishment. 3. To keep the tree free from old, non-bearing stems and branches. A well pruned tree has just enough branches to permit the free circulation of air and the right amount of sunlight.

The usual time to prune is in late winter or early spring. Some fruit growers, however, prune in the summer. To prune moderately each year is better than to prune heavily every three or four years.

A good pruner removes the branch close to the stem from which it grows. A stub should never be left sticking out from the stem. It does not heal quickly and is likely to foster the growth of fungous diseases. From your study of an apple tree you know that spurs grow out from the sides of the branches and produce the next year's fruit. Care must be

taken not to remove too many spurs and thus reduce the crop.

Spraying. Make a list of insect enemies of fruit trees. A list of fungous diseases. How may these be combated? What different kinds of sprays have you seen? What time of year are the trees sprayed? What materials are used?

A mixture designed to kill insects is called an insecticide; one to kill fungi is a fungicide.

In treating fruit trees a fungicide and insecticide are frequently combined and sprayed together. Some common mixtures are arsenate of lead and lime-sulphur; arsenate of lead and Bordeaux mixture; Paris green and Bordeaux mixture.

Fruit projects. Plan to care for your fruit trees if you have an orchard. Look after the spraying and pruning. If you lack time to care for the entire orchard choose three or four trees and see whether you can improve the quantity and quality of the fruit by your care. Keep a record of your expenditures, receipts and profits. Determine from your experience whether it pays to give some time to the care of fruit trees.

CHAPTER XVIII

DOMESTIC ANIMALS

1. Cattle

Material. Cows of the community, milk, Babcock tester, pictures of different breeds of cattle.

Study. Cattle may be grouped into two great classes; those kept for dairy purposes, known as dairy cattle, and those raised for meat, known as beef cattle. Decide what kinds are found in your community.

Make a careful study of a cow. Write the names of the different parts of the body. Note the shape of the body and the height. What sense organs have cows? Describe the eyes, ears, nose. Watch the cow crop grass. How does she do it? Watch her chewing her cud. Explain the movements that you see in the neck at this time.

Describe her feet and legs. Locate the joints in the fore leg that correspond to those in your arm. Locate those in the hind leg that correspond to those

in your leg. How many toes can you find? How many are used to walk upon?

Discussion. In order to talk intelligently about a cow and to make a score-card for judging cattle the various parts have been given names. See Fig. 58.

You find that the eyes of a cow are situated so

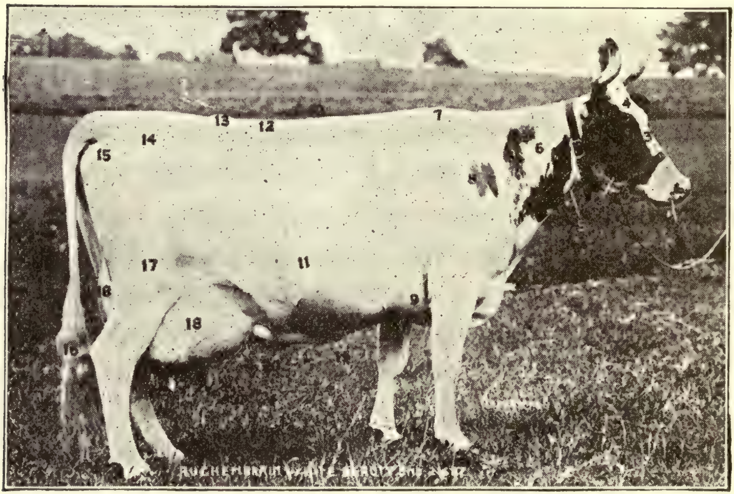

Fig. 58. Diagram showing external parts of a cow.

1. Muzzle. 2. Jaw. 3. Face. 4. Fore-head. 5. Throat. 6. Neck. 7. Withers. 8. Shoulder. 9. Chest. 10. Back. 11. Ribs. 12. Loin. 13. Rump. 14. Rump. 15. Hips. 16. Tail. 17. Thigh. 18. Udder. 19. Belly. 20. Milk Veins.

that she has a fair range of vision in all directions. She can turn her ears in any direction to catch sounds. Her hearing is very keen. The sense of smell seems well developed also. It is perhaps aided by the moisture which always stands on her nose. What animal

that uses its sense of smell a great deal has a cool, moist nose?

Cows eat rapidly and swallow their food after chewing it very slightly. This food passes into the first stomach. From here it goes into a small apartment where it is made into balls. The cow then lies down or stands quietly while she brings back to the mouth one ball of food after another, chews it, and swallows it again. This is called chewing the cud. This time it goes into the true stomach where it is digested. You can see the balls of food move upward along the neck. If you look into a cow's mouth you find eight front teeth on the lower jaw. There are no front teeth on the upper jaw. Instead, there is a hard plate. There is a space without teeth on the lower jaw. Each jaw has twelve grinding teeth, six on each side.

The cow walks on two toes. Above these you can see two other toes. The first joint in the front leg that looks as if it might be the knee corresponds to your wrist. The elbow joint is up near the body, while the shoulder joint is about half way up the side of the body. The ankle, knee and hip joints occupy similar positions in the hind leg.

A dairy cow differs in shape from a beef cow. She is said to be wedge-shaped. The wide part of the wedge is at the back, the narrow part or point in

front. A good dairyman looks for other characteristics. The cow must have what he calls open conformation; that is, a wide space between the hip bones, the ribs wide and far apart, the vertebrae long, and the paunch large and deep. She must also have distinct dairy qualities; the skin loose, dry, and flexible, the hair soft and silky, the eyes bright and projecting a little, the face smooth and the head well proportioned. The udder must be flat across the bottom, attached high in the rear, and extending well forward.

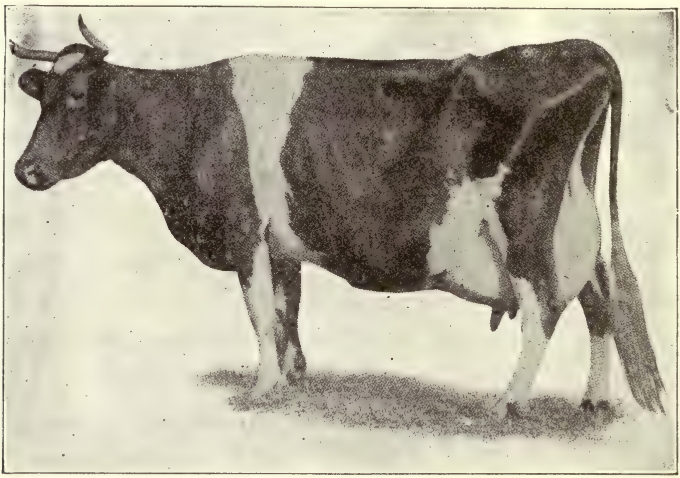

Fig. 59. A dairy cow.

The form of the beef cow makes possible the taking on of a large amount of flesh. A beef cow is almost

rectangular in form, with a short heavy neck and short legs. The body has a smooth, compact appearance.

Dairy breeds. Make a list of the dairy breeds you know. Look through farm journals and other papers for pictures of different breeds of cattle. Cut these out and group them to form a booklet.

The common dairy breeds are Jersey, Guernsey, Holstein-Friesian and Ayrshire.

Jersey cattle came originally from Jersey Island in the English Channel. They are small cows of a fawn or grayish brown color, shading toward black at the head and feet and along the back. They have black noses.

Guernsey cattle originated on Guernsey Island not far from Jersey. They are a little larger than the Jersey, are about the same color but frequently have white markings, with flesh colored noses. These two breeds are similar in the quality of milk, both giving a rather small quantity but very rich in butter fat. The Jerseys are numerous in central and southern United States, the Guernseys in the northern states and Canada.

Ayrshire cattle came originally from the county of Ayr in Scotland. They are larger than the Jerseys, are smooth, well formed cattle. The color is white with spots and streaks of red.

Holstein-Friesian came from Holland. They are

much larger than the other dairy breeds, and are black and white in color. They are the greatest milk producers, but their milk is usually rather low in butter fat.

Care and food of dairy cattle. What food do dairy cows eat during the summer? During the winter? Make a list of the different kinds of food used.

In some localities cows subsist during the summer almost wholly upon pastures. In other places dairymen do not use pastures at all but feed soiling crops and grains during the summer. In the winter hay of different kinds, grains, silage, and ground feeds are used.

It is very important that cows be fed properly if they are to keep in good condition and give a profitable amount of milk. They must have enough food and the proper kinds. This means that they must have the right proportion of protein, carbohydrates and fat.

Protein is necessary for the making of muscle, blood, connective tissue and the protein part of milk. It should constitute at least one-sixth of a cow's ration during the milking season. It may be supplied by any of the following foods: alfalfa, clover, cow-peas, soybeans, bran, cotton-seed meal, linseed meal, and oats.

Carbohydrates and fats are required for energy,

heat, fat for the body, sugar and fat for milk. Fats are found to some extent in all feeds. The common carbohydrate feeds are corn, silage, oat straw, sugar beets, and beet pulp.

When these foods are fed in the proper proportion they are said to form a balanced ration. Many agricultural stations have worked out tables of balanced rations for the use of dairymen and other farmers.

The following two tables were arranged by the Purdue Agricultural College:

Ration I		Ration II	
Corn silage	30 pounds	Sugar beets	25 pounds
Cow-pea hay	10 pounds	Alfalfa hay	10 pounds
Corn stover	2 pounds	Corn stover	5 pounds
Corn	6 pounds	Corn	5 pounds
Cotton-seed meal	1.5 pounds	Dried brewer's grains	5 pounds

A good dairyman, however, compounds his own rations to fit the weight and milk production of his individual cows. Usually a cow should be given 1 pound of leguminous hay and 3 pounds of silage for each 100 pounds of live weight, and 1 pound of grain for each 3 pounds of milk produced.

Beef cattle. There are several different breeds in America. Shorthorns are probably the most widely raised due to the fact that many of them produce a fair amount of milk as well as beef. They are of different colors, some red, some red and white, some

roan, and some almost pure white. The red ones are probably the most numerous. They are sometimes called Durhams.

Herefords are becoming more and more common in many parts of the country. They are the cattle

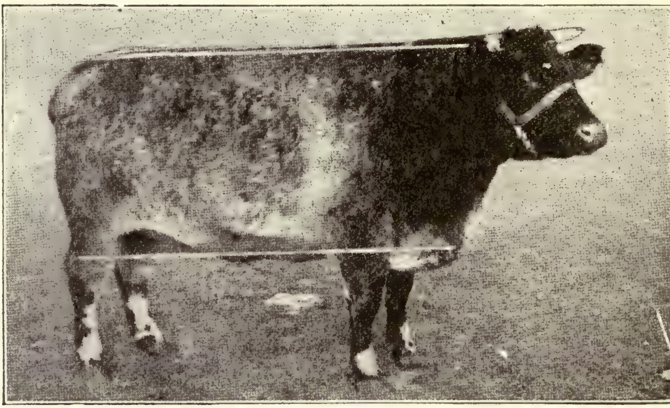

Fig. 60. A beef cow.

you often see in pastures with red bodies and white faces and legs.

We have two kinds of black cattle, Aberdeen-Angus and Galloways. The Angus are heavier than the Galloways. During the winter the coats of the latter become very long and shaggy.

The food of beef cattle. The food of beef cattle also should receive special attention. Since the object is to produce the greatest amount of meat possible, a ration is planned with this in view. More

carbohydrates and fats are fed in proportion to the protein to beef cattle than to dairy cows. Instead of feeding all grain, silage mixed with concentrated foods as linseed meal, cotton-seed meal and gluten is coming more and more into use.

Housing cattle. Housing cattle properly is quite as important as good food. A cow barn should be built so that the cows will have plenty of air and light and be comfortably warm. It should also be constructed with the idea of cleanliness. The best barns have hard floors, usually cement. The stalls have a shallow gutter at the back which slopes slightly to one end so that it may be washed out easily with a hose. In front is a water-tight trough used for food. This too has a slight slope and may be easily washed out.

Composition of milk. Of what is milk composed? You know by tasting that it is sweet. This means that it has sugar in it. We call this milk-sugar. Another of the important ingredients is fat. This is known as butter fat. There is also some protein in it and a very small amount of minerals. All the rest of the milk, by far the largest part, is water.

The following table shows approximately the proportions of each ingredient in milk of average quality:

Butter fat	4.0 per cent
Proteid	3.3 " "

Sugar	5.0	"	"
Minerals	.7	"	"
Water	87.0	"	"

Experiment. Place some fresh milk in a bottle, straight tumbler, or test tube. Allow it to stand a few hours. What happens? Why does the cream come to the top? What does a piece of wood do when put into water? Why does it float upon the water? Cream comes to the top of milk for the same reason; that is, because it is lighter than milk. Measure the height of the milk, of the cream. Calculate what per cent is cream. Cream is largely butter fat.

Separation. What methods are used in separating cream from milk? Some people use crocks or shallow pans. Fresh milk is put into these and allowed to stand. The cream rises to the top and is then skimmed off with a flat skimmer. This is the old-fashioned method but is still used by many people. It is by far the poorest method known. It has been estimated that at least one-fourth of the butter fat is left in the skimmed milk when this method is used.

Some people use a deep can, at least twenty inches in depth. The milk is placed in it and is usually kept cool by placing the can in water. Sometimes the cream is skimmed off as it is from the shallow pans, but a better way is to have a faucet in the bottom

of the can. When the cream has risen the faucet is turned and the milk is drained off. Then the cream is drawn off through the faucet. Much more butter fat is obtained in this way than by the shallow pan method.

Many people use a separator by which the milk and cream may be separated at once without allowing the milk to stand. A separator is a machine which is worked by means of a crank. The main part is a cylindrical bowl that revolves rapidly. The milk is placed in this bowl. What happens to the milk in this cylinder? Tie a piece of chalk or some other object to a string about eighteen inches in length. Take hold of the end of the string and whirl it rapidly. Can you feel the string pulling? Let go while you are whirling. What do the string and weight do? The force that made the string pull on your hand and caused it to fly off in a straight line when you let it go is called centrifugal force. It is the force that causes revolving bodies everywhere to move away from the center. Did you ever notice how mud and water fly from a rapidly revolving wheel? Since milk is heavier than cream, which will move more rapidly away from the revolving center? You can readily see that since the milk is heavier it will move toward the outside of the cylinder while the cream is forced toward the inside. There is an

opening toward the outside through which the milk pours out in a stream and an opening toward the inside through which the cream pours forth.

In many country districts milk is sent directly to a creamery instead of being separated at home. In many places large cans are furnished by creamery companies. A man comes around once each day, collects the cans of milk, and takes them to the creamery. The cream and the milk are separated at once, and usually the milk is put back into the cans and returned to the farms, where it is used to feed calves and pigs. What is done with the cream at the creamery? What is usually done with the cream that is kept at home?

Butter. Is butter made from sweet or sour cream? You know from your study of bacteria that there are organisms which under right conditions cause milk and cream to sour. Sour cream makes better flavored butter than sweet cream. In homes the cream is allowed to stand until it sours or "ripens." In creameries a small amount of sour cream, or other substance containing a number of cream-souring bacteria called a starter, is placed in the fresh cream so that it ripens in a short time.

Describe different kinds of churns that you have seen. What is the principle of churning? The cream is agitated violently enough to force the fat particles

together. They strike against each other and adhere, the particles growing larger and larger. It is not best to continue churning until the particles are all joined together in one great mass. Churning should be stopped when the particles are not much larger than a pea. If the masses are too large it is much harder to remove all the milk and water from the butter.

Care of milk. Besides the bacteria which cause milk to sour, there are likely to be many other kinds in milk, some of which produce diseases. Since bacteria find milk a favorite field, what care should be taken to prevent too many of them from getting into it? First of all, great care should be exercised in milking. The milker should have clean clothing and clean hands. The cow should be brushed to get rid of dust, and the udder should be washed or wiped clean. A covered milk pail is preferable to an open one. It is made with an opening just large enough to allow the stream of milk to flow in.

The second step in caring for milk is straining. A wire strainer should not be used. Cheesecloth and absorbent cotton make the best strainers. A layer of cotton is placed between two or four folds of cheese cloth. The cotton should be destroyed after using once. The cheesecloth should be scalded and placed in the sun. When possible all other utensils

used with the milk should be cleansed in a similar manner.

The third step is cooling. Milk should be cooled as quickly as possible. The best dairy farms have a special apparatus for cooling milk rapidly.

Experiment. To determine the effect of cooling upon the growth of bacteria in milk.

Divide a cupful of new milk into two equal parts putting half into a bottle numbered one, the other half into a bottle numbered two. Place the first bottle at once into a pan of very cold water. Leave the other in the room. When bottle number one is thoroughly cooled stand it beside number two and compare as to appearance. Which sours first? Give reasons.

The prompt cooling retarded the growth of bacteria that were in the milk. In number two the bacteria began at once to feed and multiply causing the milk to sour.

Testing the milk. In order to determine whether or not a cow is producing enough milk and butter fat to make her a profitable investment, the amount of milk should be weighed. This means that the milk of each cow should be weighed separately and a record kept. Every good dairy, or farm where a number of cows are kept, has a pair of scales hanging in a convenient place with a sheet of paper for recording

weights of milk. At the end of a season the dairyman can easily determine which cows are worth keeping and which are not.

To determine the amount of butter fat that a cow produces frequent tests with the Babcock tester are necessary. This tester may be bought for from four to ten dollars depending upon the number of bottles. Directions for using come with each machine. Any seventh or eighth grade boy or girl can soon learn to use the tester. The milk of each cow should be tested at least once a month. It will be interesting to test skimmed milk from a shallow pan, a deep can, and a separator to determine which method leaves the least fat in the milk.

Milk and health. Milk provides one of the most important foods for mankind. It is especially valuable for children since it contains all of the food nutrients needed by the growing child. Thousands of children are more or less dependent upon it for food.

Cattle are subject to the dread disease, tuberculosis, and a cow that has this disease may infect human beings through her milk. In many places herds are carefully inspected and once a year given the tuberculin test which makes it possible to detect any individuals that have the disease. These are isolated from the herd and in some cases killed.

Milk that is suspected of containing tubercular bacteria should be sterilized or pasteurized.

Sterilization kills all the bacteria, but boiling changes the flavor and digestibility of milk and is not very desirable. Pasteurization kills all active bacteria. The bacterial spores, which are inactive, are not killed and in time become active and cause the milk to sour. However, bacteria spreading such diseases as tuberculosis, typhoid, etc., do not have the spore forms and are all killed by this process.

Value of cattle. Make a list of the uses of cattle, and of the industries that are dependent upon them. These two lists will help you to realize how valuable cattle are. The most important products are milk, meat, and leather. Some of the different milk products are butter, cheese, condensed milk, milk powders, and ice cream. There are a large number of by-products. Fertilizers are made from blood and bones, the hair is used in upholstering, brush handles and buttons are made from horn and bone, glue and gelatin are made from the hoofs and connective tissue.

Projects. If you live in the country you may easily undertake one or two projects in connection with your cattle study.

The calf project is one suggested by the Department of Agriculture that may interest boys and girls. Take a young calf, care for it for a year or six

months. Keep a careful record of the feed, amount and cost.

Find the gain in pounds at the end of the period and the cost per pound of gain.

Keep a record also of the difficulties you meet and how you overcome them. Note any other facts of interest that you learn in raising your calf

A second project that is worth while is testing milk for butter fat with the Babcock tester. Several cows should be chosen and tests made of the milk. To make a fair test, samples of milk from each cow for four consecutive milkings should be tested once a month. Careful records should be kept and conclusions drawn as to the quantity of butter fat produced by each cow in a given time.

Still another valuable project is testing cows for amount of milk produced. This means taking daily weights of the milk from each cow for six months or any definite period agreed upon.

2. Horses

Types of horses. Observe the horses in your community. Are they all of the same kind or breed? State some of the differences as to size, build and color that you have noticed. These differences indicate to some extent the differences in breed. There are three important types of horses known: the draft

horse, the coach or carriage horse, and the roadster or trotter.

The draft horse is heavy, has rather short, heavy legs, a short, thick neck and broad, deep chest and shoulders. There are two other classes of heavy horses that are closely related to the draft breeds.

Fig. 61. A good farm team.

These are known as chunks and wagon horses. Chunks are light weight draft horses. Wagon horses are rather heavy but more active than the draft or chunks. Artillery horses and those used in fire departments are of this type.

Carriage horses are not common in America. More attention is given to raising them in the East and South than in the West. These horses are somewhat lighter than wagon horses, have long arched necks, and are usually of graceful appearance.

The third type, the roadster, is a tall slender horse with a small head, a long neck, and a rather thin light body.

What is the use of the roadster? The name, of course, suggests the use. This horse must be able to travel rapidly and endure the strain of travel for a long time. Why should a roadster be much lighter in weight than a draft or work horse? Do you know of any true carriage horses in your neighborhood? How do they compare with the heavy work horses and the roadsters?

Uses of horses. Observe horses in the neighborhood and note which seem to fit the description of any of these various types. Look in farm papers and magazines for pictures of horses of different kinds and start a chart of these as you did of the different breeds of cattle. What are the uses of the different kinds? The largest draft horses are used in large cities to draw immense loads of various kinds. Do you know how much a heavy draft horse weighs? The heaviest draft horses weigh over 2,000 pounds, medium drafts from 1,600 to 1,700 pounds, and light

draft from 1,500 to 1,600 pounds. Do these horses move rapidly or slowly?

Make a list of the different kinds of work that farm horses do. Is any work now done by horses that was once done by man? Inquire of your parents in regard to this matter. Perhaps some of them will remember when corn was planted by hand and all small grains sowed broadcast by hand. To what extent have gasoline or steam engines taken the place of horse power in your neighborhood? Think of tractors, threshers, corn-shellers, automobiles, etc. While you do not remember, your parents will, that not many years ago all threshing machines and corn-shellers were run by horse power.

Description. Study a horse. Use good pictures if you do not have an opportunity to study a live horse. Make a list of the parts with a description of each. How high is the horse? Compare the length of the legs with the height. Note movements of the ears. What is the advantage in the position of the ears? Describe the eyes, the nostrils. Note the thick lips and the teeth. How many front teeth do you see? Note the body covering. What are the uses of the mane and tail?

Examine the feet and legs. Note differences between the front and hind legs. Determine the joints corresponding to those in your own body. Show how

the leg and foot of a horse are adapted for speed and for travel upon dry ground. How does the tail differ from that of the cow? Compare the foot of the horse with that of the cow. Which foot will endure more travel on hard ground? Which will likely bear the animal up better on soft ground? Why?

Discussion. The horse is among the best loved of all domestic animals. In some ways it seems more intelligent than other animals. It is high-spirited and sensitive. You noticed how the ears move as if they were on a pivot, ready to catch every sound. The eyes are placed so as to give a wide range of vision. The nostrils flare. The sense of smell is very keen. The long legs and comparatively light body show that the horse is well adapted for travel. The height of a horse is measured in hands. One hand is four inches.

The teeth of the horse are interesting. When a horse is full grown he has forty teeth. On each jaw there are six incisors, two canines, and twelve molars. The incisors are prominent and sharp enabling the horse to crop grass very close to the ground. A man who knows horses can tell the age of a horse by examining the incisors. A colt's teeth are temporary and are gradually replaced by the permanent set.

The middle pairs of permanent incisors, above and below, appear when the horse is three years old; the

next pair at four, and the third pair at five years. The new teeth have deep cups or indentations in the middle of the biting surface. As the teeth are used the sides wear down and the cups gradually disappear. When the horse is six years old the cups in the middle pair of teeth on the lower jaw have disappeared. At seven the cups are gone from the second pair. At eight the cups have disappeared from all the lower incisors but are still present in the upper jaw. At nine they are gone from the upper middle pair, at ten from the second pair, and at eleven from the third pair. After this the shape and direction of the teeth indicate something of the age.

The horse walks on its middle toe, which is large and has developed a horny covering called the hoof. The rudiments of two other toes can be seen at the back of the foot.

The joints about half way up each leg correspond to our wrist and ankle joints. The elbow and knee joints are close up to the body. The round hoof of the horse is adapted to travel on dry plains, while the split hoof of the cow is adapted to wet marshy places. The long leg is adapted for rapid travel.

The body is covered with short hairs that lie close to the skin. When properly cared for they make a beautiful, glossy coat. The hair is shed every year. It is much thicker in the winter than in summer.

Care of horses. One of the first things to consider in caring for a horse is its food. Make a list of the various foods horses eat. List the kinds of hay used in the neighborhood. How many feed timothy alone? Clover alone? Timothy and clover mixed? Alfalfa? Straw? Who feed oats? Who corn? Compare these foods as to the amount of different nutrients. Which contain the greater amount of roughage? Grains contain a high per cent of carbohydrates and not much protein. Leguminous hays contain proteid and all hays roughage. Since carbohydrates produce fat and heat, you can see why foods containing carbohydrates should be fed to horses in greater quantities in winter than in summer. Why do working horses need different kinds of food and larger amounts than idle horses? When a horse is working he is using up muscle just as boys do when they exercise. Therefore a working horse should be fed more proteid foods because these foods help to build up muscle. He also needs carbohydrate and fats to supply energy. Like most animals, the horse needs some salt, and a small amount should be given him at least every two weeks.

Balanced rations have been arranged for horses as well as for cattle. A 1,200 pound horse at heavy work requires 2.16 pounds of proteid, 14.4 pounds of carbohydrates, and .6 pounds of fat. On this basis the following rations have been worked out:

No. 1	Pro.	C. H.	Fat.
Oats, 18 pounds	1.65	8.46	.75
Timothy hay, 14 pounds	.39	6.08	.19
No. 2			
Corn, 15 pounds	1.18	10.00	.64
Clover hay, 14 pounds	.95	5.02	.24

By adding the columns you find that each ration approximates the amount required. The farmer should use the ration that is most economical for him.

It is of great importance to observe regularity in the feeding of horses. Horses more than any other domestic animals seem to like order and regularity. They seem to watch and know when feeding time has arrived and become nervous if they are not fed. The horse should receive its heavy meal at night after the day's work is done. There is a good reason for this. The stomach of the horse is small compared with that of other large animals; hence when horses are fed in the evening they have plenty of time to chew and digest their food. A good rule to follow for a working horse is to feed one-fourth the daily ration in the morning one hour before going to work, one-fourth at noon, and one-half in the evening.

The same care should be exercised in watering horses as in feeding them. Most experts agree that horses should be watered before meals rather than afterwards, the only exception being, perhaps, with the morning meal. Great care should be taken to

avoid watering horses when they are very warm. A good horse may be ruined, sometimes killed, by drinking a large quantity of water when in a heated condition.

Horses should be housed in comfortable, well-aired barns. They should be kept clean by currying and rubbing twice a day, and the legs should receive special attention. A rubbing down is quite necessary in the evening after the day's work. The horse will rest much better and be in better condition for work the next day. During cold weather horses should be blanketed when standing still, especially when they have traveled some distance and are warm and perspiring.

The harness. Harness has two uses; one is to enable the horse to do its work, the other is to enable the driver to control the horse. Name all the parts of the harness you know. What parts help the horse in pulling a load? What parts aid the driver in controlling the horse? What parts of the horse are likely to be injured by poorly fitting harness?

Discussion. Since the horse uses its shoulders in moving a load, the collar, hames, and traces are the parts that aid it most. The bridle, bit, and lines enable the driver to control and guide the horse. Many horses suffer greatly because the harness does not fit properly. A poorly fitting collar results in a

sore neck or shoulder. If the bridle and bits are not right a sore mouth will result. An improperly fitting crupper may result in a sore tail. A riding horse should have a saddle that fits properly.

Harness should be thoroughly cleaned and oiled to prevent its becoming hard and stiff.

Training horses. Bad habits in horses are usually due to improper training. It should always be remembered that horses rarely forget a trick or anything that they have once experienced. If they become frightened at a piece of paper in the road and run away they are very likely to be frightened the next time they see a piece of paper. Thus it is very important that horses should be trained carefully so that they may have nothing to remember that will later be injurious either to themselves or to their owners.

In breaking a horse one should be firm yet kind and gentle. Horses should be trained to stand still while being harnessed, to stop promptly at the word "whoa," and to move backward at the word "back." A horse properly trained will not start forward until he is given the word or signal to start. Have you not seen horses that began to move the moment the driver took the lines in his hand, instead of waiting to be told to go? Every farm boy should learn how to manage a horse and do it in the right way.

History. Horses have been known since the begin-

ning of history. Our ancestors in prehistoric times tamed wild horses and used them in hunting other animals that ran rapidly. The horse is one of the fleetest runners known among animals.

The horse was brought to America from Europe. In Europe there are two distinct types of horses: a heavy horse that was found in England in the western part of the continent, and the Arabian horse that was brought into Europe at the time of the Crusades. The wild horses that we read about in America were horses that escaped from the early Spanish explorers and roamed over the prairies until they became wild.

Colt project. Any boy or girl who is interested may with profit undertake a colt raising project similar to the calf project. Records should be kept of the cost, the management, and the condition of the colt at the beginning and the end of the peirod.

3. Swine

Material. Hogs of the neighborhood, pictures of mature and young pigs.

Study a hog. Note the shape of the body, the length and size of the legs, the body covering. How does the hair compare in thickness with that of a cow? Examine the feet. Find the number of toes.

Decide on what part of the foot the pig walks. Has the divided hoof any advantage for the hog? Are the rear toes of any use? What is the shape of the face? Describe the ears, eyes and nose. Look especially at the end of the nose. Note the position of the mouth.

Make a list of the different kinds of food that pigs eat. Describe their habits of feeding. How does the nose aid in obtaining food? Determine whether or not all the different classes of teeth are present. Describe the habits of pigs with reference to mud and water.

How many different breeds of hogs are represented in your district? How do they differ in shape, size, color, etc.? What is the greatest number of hogs kept by any one farmer? For what purpose are they kept? At what age are hogs usually marketed? What is fed to hogs that are being fattened for market?

Discussion. Hogs or swine have been domesticated since a very early time. Their origin is not definitely known. It is believed, however, that they were first domesticated in Asia and are descendents of the wild boar. (Note that the term boar originally had the same meaning as our word hog.) It is also probable that later the wild swine of Europe was domesticated in that country. Wild hogs are still found in some parts

of Europe and Asia, and in some of our southern and southwestern states. These latter are not native to America, but are the descendants of the domestic hogs that were brought over here by the early Spanish explorers. These hogs, like the wild hogs of Europe, are thin and sharp-nosed. They are commonly known as razor backs. They subsist upon herbs, nuts of trees, roots, and insects found in the soil.

The body of the hog, as compared to the height, is long and deep. The legs are short and each foot has four toes. The two front toes are large and it is upon these that the hog walks. The hind toes are small and placed higher up than the front ones. They are of no use when the hog walks on dry land, but when it walks on low, marshy ground these hind toes help to keep it from sinking into the soft earth.

The body is covered rather scantily with very stiff hairs called bristles. They are strongest and stiffest along the back. Under the bristles is a thick leathery skin. On most hogs the hairs are so scattered that the skin shows through plainly over the entire body.

The bristles of the hog are used in the making of brushes. Shoemakers use them in making wax-ends with which they sew shoes.

The general shape of the head of the hog is tri-

angular, the forehead curving inward and the cheeks outward, more or less according to the breed. The ears are of interest because of their large size. In some breeds they stand up, while in others they droop. This characteristic aids in distinguishing breeds. The eyes, though small, have a keen vision. The nose is one of the pig's most interesting features. It ends in a fleshy disk, often called the snout. This is exceedingly sensitive so that it can detect the solid grains of oats or wheat in a pile of chaff. It is also so strong the hog can turn over sod or dig down into the soil from six inches to two feet. In order to keep hogs from killing out pasture in which they feed, rings are put into their snouts to keep them from "rooting." The sense of smell is very well developed. Hogs are said to be able to follow scent quite as well as a dog. The mouth opens under the snout. All the different kinds of teeth are present. There are six incisors, two canines and seven molars on each jaw. The canine teeth in the upper jaw turn upward. In the males these teeth grow quite long and are called tusks. In the wild boar the tusks are very large and are strong weapons of defense.

Hogs have formed the habit of wallowing in mud and water for two reasons. One is that they do not perspire as some other animals do, and to keep cool they lie down in water and mud. The other reason

is that the hair on their bodies is so scattered that flies and other insects have easy access to the skin. They get into the mud and water to protect themselves from insect pests.

Breeds of hogs. There are a number of different breeds in the United States, most of which have been developed here. The favorite black breeds are the Berkshire and the Poland-China. Both are black with white spots or bands over the body. The Berkshire has erect ears, while those of the Poland-China are drooping. They are both rapid growers.

Fig. 62. Poland China, a lard type of hog.

The most favored white breed is known as the Chester White. Hogs of this breed are somewhat slow maturing but are hardy.

The Duroc-Jersey is of a reddish brown color. It has a large frame and is easily raised. It is becoming a great favorite in many parts of the Middle West.

All of the breeds named thus far belong to the lard or fat type. There is another class of hogs known as the bacon type.

The fat hog has a thick, deep body, strong hams,

short head, and short legs. The bacon hog is not as broad as the fat hog, and has longer sides, lighter hams, and longer legs. Throughout the corn belt the fat type is raised almost exclusively. Farther north some of the bacon types are raised. In some parts of the East and in Canada the bacon type is more

Fig. 63. Large Yorkshire, a bacon type of hog.

common than the fat hog. Among the best known bacon hogs are the Essex, the Hampshire and the Tamworths.

Care of hogs. How are hogs cared for in your neighborhood? How are they housed? Describe any hog houses that you have seen.

Farmers are everywhere giving more attention to the care of their hogs. Formerly any place was thought good enough for these animals. Now, good houses that will admit plenty of sunshine and air are finding favor. These houses are constructed so that the hogs may have a warm, dry shelter during the winter and cool spring months. The most approved houses are long buildings facing the south, and divided into pens from five to eight feet wide and

Fig. 64. A good hog house.

from eight to twelve feet long. From each pen there is a door leading to an outside run. The floors are usually cement, although some are of wood. Troughs for semi-liquid food and for water are placed along the sides of the pens.

Food for hogs. While pigs are young they should be fed milk and a little ground feed such as shorts. Later, especially when they no longer depend upon

their mother's milk, they should be fed milk and ground feeds with a little dry grain such as oats, and if possible they should be allowed to run on pasture. At this stage in their lives, when they are growing rapidly, pasturage and other succulent foods are excellent for them. When they are from six to seven months old they are ready to fatten. They should now be fed much more corn and should no longer be allowed to run in the pasture. Some tests show that alfalfa fed with corn gives excellent results.

Diseases. Hogs, more than any other domestic animals, are subject to a number of diseases. The one most dreaded is cholera. It frequently kills off an entire herd within a few weeks. This disease is due to bacteria and is very contagious. The bacteria may be carried by animals that go from one farm to another as dogs, cats, pigeons and other birds that feed in the hog lot. Men may carry them on their shoes as they walk about in soil and debris. Whenever cholera is in the neighborhood, the greatest care should be taken to prevent its spreading. The most effective means now used to prevent the disease is vaccination. A serum is injected into the blood of all well hogs which acts in much the same way that anti-toxin acts to prevent diphtheria. If it is suc-

cessful, the hogs are immune from the disease for a number of months.

Value of hogs. How valuable are hogs to the average farmer? What are they worth? What is a good average weight when the hog is ready for market?

When managed properly hogs bring excellent returns to the farmer. The price varies from time to time as with every other farm commodity. It is usually quoted at so much per hundred pounds. It has sometimes been as low as four dollars per hundred, but often reaches six, eight and even twelve dollars. Recently hogs have sold on foot as high as twenty dollars a hundred. A good average weight of fat hogs from seven to nine months of age is from two hundred and fifty to two hundred and seventy-five pounds. Older hogs weigh from three to five hundred pounds.

Booklets and charts. Make a collection of pictures showing different breeds of hogs, hog houses, hog cots, etc. Paste these on sheets of heavy paper and label carefully.

Project. No other farm animal lends itself so readily to boys' and girls' projects as a pig. Procure a pig a few months old. Feed it till ready for market. Keep a record of feed, other expenses, weight gained, and profits.

4. Sheep

Material. Sheep of the neighborhood. A portion of a fleece. Pictures of sheep.

The sheep as a type of animal. Make a study of a sheep. Note all the parts and describe each. If you do not have access to a living sheep procure some good pictures and study those.* Note the shape of the body, the length of the legs, the thickness of the legs, the position and manner of holding the ears, the shape and color of the nose, and the size and appearance of the eye. Study the woolly coat, its color, thickness, difference between outer and inner portions, variations on different parts of the body.

Note the difference in appearance between the male and female sheep. The males are known as rams, the female are ewes.

Study a lamb comparing with the adult.

What do sheep eat? What other domestic animals do they resemble in their habits of eating?

How many farmers in your community keep sheep? What different breeds are represented? For what purpose are they raised? How old are the sheep when marketed for mutton? At what season are sheep sheared? How is it done? What is done with the wool? How much wool will one sheep produce at one shearing?

*Look in a large dictionary for pictures of types of sheep.

History. Sheep are among the oldest domestic animals. As far back as we can go in written history we find sheep mentioned. The exact origin of our domestic sheep is not definitely known. It is thought that they originated from wild sheep of Asia and Europe. Some believe that the European breeds have been developed largely from small wild sheep which even yet inhabit the mountains of Greece, and the islands of Crete, Cypress and Corsica. Our American breeds have been introduced from Europe.

Discussion. In their wild state sheep fed upon the scant plant life found in mountainous regions. For that reason the domestic animals are able to subsist where cattle and horses would almost starve. They eat all sorts of weeds as well as grain and clovers. In the woods they eat young trees and shrubs and all kinds of undergrowth.

The arrangement of the teeth is similar to that of the cow. There are eight incisors on the lower jaw, but there are no upper front teeth. There are six back teeth or molars on each half jaw. The small sharp pointed front teeth enable sheep to crop very small plants close to the ground.

In feeding habits sheep resemble cattle; that is, they eat rapidly swallowing the food with little chewing. Later they bring the food in small lumps back

to the mouth and chew it as they lie in the shade or stand together resting. As in the case of cattle, this process is called chewing the cud.

Sheep can readily climb hillsides and the rugged surfaces of mountainous regions. Their thick coat of wool makes it possible for them to live comfortably in cold regions and in high elevations.

Their native homes probably account for the well developed muscles in the legs which enable them to jump over crags and across ravines. The foot below the ankle joint is small and delicate. It has two toes upon which the animal walks. If you look closely you find small, rudimentary toes above and to the back of the front toes. The hoofs are kept oiled by a small gland that lies between the toes.

If you observed a lamb you noticed that its legs are very long compared to the size of the body. For this reason a very young lamb can walk almost as far during the day as the older members of the flock. Lambs are very active, skipping, jumping, and playing constantly with each other.

Lambs have quite long tails but these are cut off while the lambs are young. This is to prevent burs and filth from collecting on them and producing disease.

Types of sheep. We have two distinct breeds of sheep; those that are raised chiefly for their wool, and

those that are raised for their meat. They are known as the wool type and mutton type.

The wool type is represented by the following breeds: Merino, Delaine Merino and Rambouillet. Their bodies are angular and thin; the skin is often wrinkled so as to form folds. The build of the body gives a large surface for the attachment of wool. The wool itself is of a superior quality.

Sheep of the mutton type have rectangular bodies built somewhat on the plan of beef cattle, so that they produce a large amount of mutton. They are divided into two classes, those that have wool of medium length and those that have long wool. The most common of the former are the Southdown, Oxford and Dorset; of the latter, Cotswold, Leicester, and Lincolns.

Care of sheep. Of all domestic animals sheep are the most easily cared for. Their feeding habits enable them to clean up fields where other animals can no longer find sufficient food. They thrive best on a mixture of hay, oats, some corn and silage. If they are being fattened for market they are fed more grain and less roughage. Lambs may be ready to put on the market at from seven to twelve months of age.

Some sheep raisers make quite a profit by fattening young lambs and selling them at from six to ten

weeks old. Their meat is considered very choice and brings a high price.

Because of the warm coat, sheep require less shelter than other animals during the winter. An open shed may be used. It is quite essential, however, that it be kept perfectly dry.

Sheep that are kept for producing wool are sheared in the spring. A good Merino fleece weighs from twelve to twenty pounds. Some of the mutton breeds do not yield more than eight pounds of wool. The wool of the Merinos is used for the finest grade of wool cloth. The mutton breeds produce a coarser wool and the cloth made from this is usually of a rougher weave.

A good fleece should be thick and even over the whole body. It should have a strong well-crimped fiber of bright appearance, and should contain enough oil to preserve and keep the fiber strong.

It is said that a farmer who knows how to manage his flock can make the wool pay for the feed, leaving the lambs raised as clear profit. Lambs are usually sold in the fall so they will not have to be sheltered and fed over winter.

Wool. Study a piece of wool taken from a sheep. How does it differ from hair? If possible examine it with a hand lens. How does wool cloth feel? Compare with cotton and silk.

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Wool. Study a piece of wool taken from a sheep. How does it differ from hair? If possible examine it with a hand lens. How does wool cloth feel? Compare with cotton and silk.

Wool fibers have little scales or projections along the sides, while a hair is smooth. These scales make wool feel rough against the skin.

Make a list of all the things you know that are made of wool.

Sheep industry. Sheep raising is not as great an industry in United States as that of swine. Farmers are beginning to realize, however, that a flock of sheep on the farm is a paying investment. The eastern states and those of the Middle West for the most part raise the mutton types. In the far West more Merino sheep are raised. Here are great ranches where several thousands of sheep may be found in one flock. In the summer the herders with their faithful shepherd dogs take the flocks to the mountains and hillsides where they feed upon the scant vegetation. In the winter they are brought down to the valley where they are sheltered and fed.

Projects. The raising of lambs either for meat or wool production is a project well worth undertaking by any boy or girl who lives in a region where sheep are raised.

Choose for the project one or more spring lambs and care for them until ready to market for mutton, which will be from six to eight months. Keep a record of expenses; cost of feed, labor, receipts, and profits.

Instead of selling the sheep for mutton you may keep them for their wool and to produce lambs.

Keep a record of your expenses, receipts and profits. Take into account the value of the sheep and lambs produced.

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WINTER STUDIES

CHAPTER XIX

LIGHT AND LIGHTING

Materials. An ordinary candle, several small Christmas candles, kerosene lamp, gas fixture, electric light bulb, test tube, rubber stopper, glass tube, small pieces of soft coal.

Study. What method of artificial lighting is used in your home? In your school building? Make a list of all the different methods of lighting that you know. Group them into two classes: 1. Those in which the light is directly produced by a flame. 2. Those that produce light in some other way.

The candle. Study a candle that has not been used. Of what is it made? Examine the wick and describe it. What is the shape of the candle at the top? At the bottom? How was it made? Light a small piece of candle. Watch very carefully to see what happens till the flame remains steady. After it has burned a short time notice the top of the candle. What is in the hollow cup? What forms the sides of the cup? How close to the cup does the flame

extend? How high is the flame? Describe its shape. Where is it widest? Where narrowest? What different colors do you see in it? How does it look at the center? Make a drawing to show all the parts you have observed.

Experiment. What produces the candle flame?

When your candle has been burning for some minutes blow out the flame. What do you see coming from the end of the wick? What color is the smoke? What do you think this smoke is? Examine the warm wick and determine what is in it. Explain the relation between the melted paraffin in the wick and the smoke or vapor coming from it.

Relight the candle and allow it to burn for a minute or two, then blow out the flame. Have a lighted match ready and the moment the flame is out apply the match to the smoke. Describe what happens. Try this again and again till you make up your mind what it is that really burns and makes the flame.

Experiment. Will liquid paraffin burn? If you are not quite certain whether it is the melted paraffin or the vapor of paraffin that burns, make this experiment. Melt a little paraffin in a tin cup or deep spoon. Apply a lighted match to see if it will burn. How many different forms of paraffin are present in the burning candle? What besides the paraffin vapor is needed to make the candle flame?

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Explanation. When you lit the candle the heat of the match melted the paraffin or tallow in the upper part of the wick and a small part of the liquid changed to vapor and began to burn. The heat from this melted more paraffin and more vapor was formed. Presently there was sufficient heat to melt the paraffin around the wick and form a cup at the top of the candle. The liquid paraffin was absorbed by the wick, was changed to vapor at the top and burned. This explains why the flame is small at first but gradually increases in size till there is a steady supply of vapor at the top of the wick.

You noticed that the burning seems to take place along the outer portion of the flame. The inner dark portion is the paraffin vapor or gas that is not burning. You have already discovered that air is necessary for burning to take place, so it is easy to see why the burning is at the outer portion where there is a constant supply of fresh air.

Experiment. What is meant by candle power? Darken the room as much as possible. Light an ordinary candle and place it on a table. On the same table about two feet from the first candle place a lighted Christmas candle. When both are burning brightly open a book on the table about half way between the two lights, and begin to read. When you have read about a minute have some one extinguish

the flame of the larger candle. Continue to read. Have the person relight the larger candle and after a few moments extinguish the flame of the small one. What difference do you notice as to the strength of the light from the two candles?

Candle power. You often hear people speak of the candle power of different kinds of light. The electric lights used in our homes are commonly 8 or 16 candle power. A standard candle is used to measure the intensity of light. Your simple experiment with the two candles proved that there is a great difference in the intensity of light given out by different lighted bodies. Scientists by careful measurements decided on a standard with which to measure the illuminating power of artificial light. One candle power is the amount of light emitted by a sperm candle seven-eighths of an inch in diameter and burning 120 grains of sperm oil per hour.

Lights used in early times. Before the candle came into use, a very crude form of lamp was used for lighting. This consisted of a vessel containing melted fat, into which a piece of twisted cloth was thrust for a wick. This primitive lamp was really the forerunner of the candle. In the early pioneer days of our country, before primitive lamps and candles came into use, homes were lighted by pine knots or by the light which came from the fireplace.

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At first candles were made by a process called dipping. Tallow was melted in a large iron kettle. Strings, sometimes as many as a dozen at once, were tied to sticks a foot or two in length and dipped into the hot tallow. Then they were taken out, hung up a few minutes until the tallow hardened, when they were dipped again for a moment. This process was repeated again and again till the candles were of the necessary size. You can imagine how much time was required to dip enough candles to last the family for a whole year.

After a time candles were made by molding. I wonder if any of you may have in your home an old set of candle molds? The molds were first strung with the wicking, then the melted tallow was poured in. The candles we use today are made in molds but the work is done in factories instead of at home. Most candles we have today are made of paraffin instead of tallow.

Paraffin is made from crude petroleum or crude oil. It melts at a high temperature. When the candle is burning the heat from it melts the paraffin around the wick. This is changed to vapor or gas at the top of the wick; so you have in a burning candle an excellent example of the three forms in which matter of any kind may exist; solid, liquid, and gas.

The kerosene lamp. Study a kerosene lamp which

is about half full of kerosene. Write the names of all the parts and try to determine the use of each. What is in the bowl? In the upper part of the wick? Light the lamp and compare the flame with that of the candle.

Experiment. To determine the use of the chimney. Light the lamp and put the chimney in place. Watch the flame to determine whether or not it is steady. Extinguish the flame and remove the chimney. Relight the lamp. Try this several times, in a draft and in quiet air, till you are certain that the chimney has a special use.

Experiment. To determine what burns to produce the flame.

Light the lamp and do not put on the chimney. Blow out the flame as you did in the candle experiment, and by trying to light the gas or smoke that comes from the wick determine whether it is the liquid kerosene or the gas that burns and makes the flame.

Experiment. Look carefully at the burner to determine whether any provision is made for the admission of air to the upper part of the wick. Trace the air from the outside into the chimney. To do this light a small splinter of pine wood, a twisted paper lighter, or a piece of punk. Allow it to burn a few moments, then blow out the flame and hold it below

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the burner. Watch to see where the smoke enters the chimney. Hold the smoking splinter above the chimney to determine the direction of the air currents there. What causes the air to move through the base of the burner toward the flame?

What is kerosene and how is to obtained?

Explanation. You probably have decided from your experiments that the chimney and burner together regulate the amount of air that is brought to the flame. The openings in the base of the burner allow the cool air from below to enter and the cap directs the air toward the flame.

You proved by experiment that it is the gas or vapor of kerosene that burns and not the liquid. The fact is that every flame in the world is produced by burning gas or vapor.

Kerosene is another product of petroleum or crude oil. Look in your geography to find out where the great oil fields of United States are located and make a list of all the uses of crude petroleum. Perhaps you are near enough to a region where there are oil wells to visit them and see how the oil is obtained.

Crude petroleum is a mixture of a number of different liquids. To obtain these the petroleum is heated and the liquids are changed into vapors. The vapor is caught in large vessels where it condenses and changes back into a liquid. The lightest liquid

changes to vapor first and is caught by itself. Gasoline is lighter than kerosene, so it vaporizes first and is obtained before kerosene.

The process of separating a mixture of liquids by vaporization and then condensing them is called distillation.

The main products distilled from petroleum are: light gasoline, heavy gasoline, naphtha, kerosene, vaseline and paraffin.

Gas lamp. Study an ordinary gas lamp used for lighting homes. Write the names of the parts.

Light the lamp. Can you see a flame? What produces the light? Remove the mantle from the burner. (This must be done very carefully or the mantle will break.) Now turn on the gas and light it. What is the color of the flame? Does it give a good light? Examine the lower part of the tube which leads to the flame for air openings that might admit air into the tube. If you have an ordinary gas jet that does not have a mantle or globe, light it. What is the color of the flame? Does it have an opening in the tube to admit air? What really happens when you turn on the gas? Find the gas pipes and meter in the basement. What is the meter for? Is the gas that you use manufactured or natural? How is manufactured gas sold?

Experiment. To generate coal gas. Procure a test

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tube, a rubber stopper with a hole in it, and a piece of glass tubing about six inches long that fits tight in the stopper. Place a piece of soft coal about the size of a hickory nut in the test tube. Put in the rubber stopper. Hold the test tube almost horizontally, tipped slightly downward at the mouth. With an alcohol lamp heat the coal. When the vapor comes out of the tube light it and you have a small gas jet.

Explanation. Most gas lamps have a mantle which conceals the flame. The flame is what is known as a blue flame. It is very hot but not bright so it gives a very poor light. But the mantle becomes so hot that it glows with a white heat and produces a very good light. With this kind of a light the air enters at the air openings on the side of the tube. When you turn the gas on it mixes with the air before it reaches the flame. A lamp that has the air and gas supply mixed in proper proportions makes a hot blue flame.

In the open jet the air mixes with the gas as it burns. This produces a flame similar to that of the candle or kerosene lamp. It does not produce as good a light as the lamp with the mantle and it burns more gas.

Different kinds of gas are used for lighting purposes. Some people have their own gas plants and generate a gas out of gasoline. Others have acetylene

gas machines. In some places natural gas that is found far down in the earth is used. Wells are sunk and the gas piped from them to buildings. Many towns and cities manufacture gas from coal or other materials and pipe this to homes and other buildings. It flows through a meter in each house and by a device the amount used is measured in cubic feet. The price of gas varies in different places from eighty cents to one dollar and twenty-five cents per 1,000 cubic feet.

Electric lights. Examine an electric light bulb. What do you find? Turn on the electricity. Is there any flame in the bulb? What produces the light?

Experiment. A light without a flame. Put an iron poker in the stove or furnace and allow it to remain until it is very hot, then take it out and hold it, heated end up, in a dark room noting the light that it gives out. If there were some way that you could keep it white hot would it light a room fairly well? Is it burning? How does it make light?

What happens when you press the button or turn the electric switch? Where does the electricity enter your home? How many wires are there? To what are the wires connected inside the building? What is the use of the meter?

Study the street lights in your town. Are they all of the same kind? Compare with one another and

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Study the street lights in your town. Are they all of the same kind? Compare with one another and

with those used in your home or other buildings. In each case determine the route by which the electricity gets from the power house to the lamp.

Explanation. In cities, and even in some rural districts, electric lights are fast taking the place of all other kinds because they are most convenient and give the best light in proportion to the cost.

You observed that the light in the bulb is made by a fine wire, which becomes very hot and glows just as the end of the poker did in your experiment. When you press the button you cause a current of electricity to flow through the wire in the lamp, and this causes the wire to become hot. There is no burning connected with it. When a body is heated to a white heat, it is said to be heated to incandescence; so this kind of electric light is called an incandescent light.

The electricity is generated in the power house and flows along wires in the street or ground known as line wires. Other wires extend from these to the buildings. When you press the button you simply connect the line wire with the lamps so that the current may flow through it. Electricity flows more readily through copper than through other metals. The finer the wire the more resistance is offered to the current. Line wires are made of rather large copper wire. The incandescent lamp has either a very fine carbon or tungsten filament which offers such a

great resistance to the current that it becomes very hot and thus gives light. Tungsten is coming into use more and more since, with the same strength of electricity, it gives almost three times as intense a light as the carbon. It is more expensive, but because of its greater efficiency it is more economical in the long run.

Eyes

Look into a mirror and note all the different parts of your eye. Look at an eye of one of your classmates.

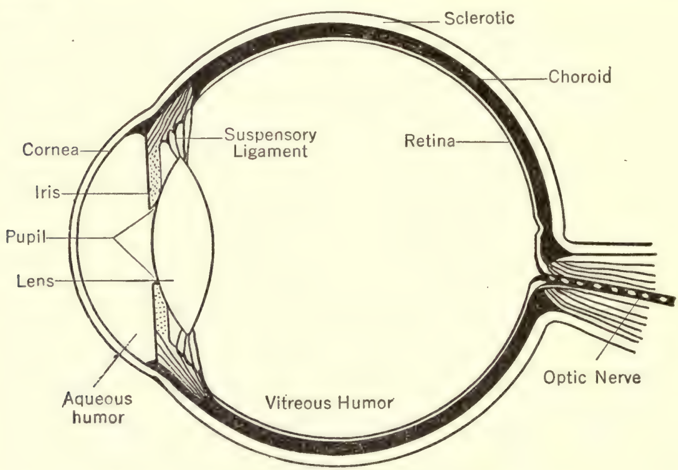

Fig. 65. Section of the eye.

The parts that you can see are: (1) The eyelids with their lashes. These are to protect the eye from dust and other foreign objects. (2) A small part of

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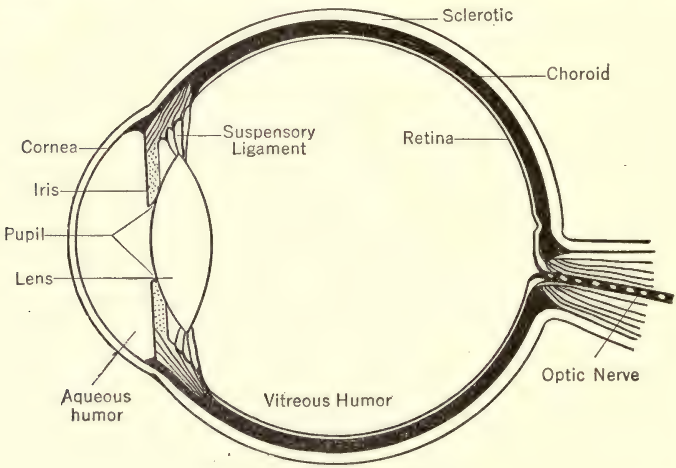

Fig. 65. Section of the eye.

The parts that you can see are: (1) The eyelids with their lashes. These are to protect the eye from dust and other foreign objects. (2) A small part of

the eyeball with the white covering. (3) In front you see the colored part of the eye known as the iris. In the center of this is the dark round spot called the pupil. The iris and pupil are covered with a transparent covering called the cornea. If you could see your entire eye you would find that the ball fills a bony socket which you can feel surrounding the eye. On the inside of the ball back of the iris is a little watery fluid and back of this is a lens known as the crystalline lens. The rest of the ball is filled with a semi-liquid substance somewhat clearer than the white of an egg called vitreous humor. On the inside of the wall next to the white coat is a dark coat and inside of this is the retina, which is really the spread out optic nerve.

Rays of light pass from any object you are looking at through the pupil, then through the lens and an image of the object is thrown upon the retina. This in some way stimulates the optic nerve which carries the sensation to the brain and thus you see the object. The plates or film of a camera receive picture impressions in much the same way that the retina does.

Care of the eyes. Eyes are such delicate yet wonderful devices for seeing that they should receive the greatest care. They may be permanently injured by using them in a bad light. People everywhere are giving more attention to the proper lighting of homes,

schools, libraries and other buildings. Light that comes from above is better than light that is on a level with the eyes. Window shades in many schools are adjusted so that the lower part of the window may be covered with the shade while the upper portion admits the light.

The light from an ordinary kerosene lamp, gas jet, or clear glass electric bulb is called direct light. If the direct rays are broken up by reflection from an uneven surface, as a papered wall or ceiling, or by passing through white or frosted globes or window curtains, the light is diffused. Diffused light is much better for the eyes than direct light.

Study the lighting arrangements in your home and school. Decide which kind of light you are using.

Placing a shade over an ordinary lamp will aid greatly in softening and diffusing the rays. In using any artificial or natural light sit so that the light will strike your work over the left shoulder. Reading while lying down causes a great strain upon the eyes.

Whenever there are any indications that something is wrong with the eyes, an oculist should be consulted at once. In many schools children's eyes are tested once each year. Many really bright pupils are considered dull simply because their eyesight is defective and they cannot see well enough to do their work properly.

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CHAPTER XX

WATER SUPPLY

Materials. The water supply of the school and home; a faucet, drinking fountain; water pipes, reservoir, standpipe; wells, pumps.

Water supply of the school. How are you supplied with drinking water in your school building? If from a pail or jar, what precaution is taken to keep it free from dust? Are individual drinking cups used? How do you get the water from the pail into your cup?

If you have a drinking fountain, study it. How many distinct parts do you find? How many pipes are connected with it? What is the use of each? Of the basin? When you turn the faucet what happens? Why does the water flow out? Where does it come from? How do you stop the flow? To answer this, examine an unattached faucet. Look through it while you turn the handle back and forth.

Study faucets at home. Can you turn the faucet and leave it so the water will continue to run until you turn it back, or does the water stop running the moment you stop pressing on the handle or

spigot? Where does the water come from that stands in the pipe ready to flow the moment you turn the faucet? Does the water flow slowly or rapidly? If there are fountains or lavatories on different floors of the building, test them to determine whether there is any difference in the force with which the water flows.

Trace the water-pipe to the basement of the building. Find where it enters. How deep in the ground is it? What is the size of the pipe? When a plumber speaks of an inch and a quarter pipe, does he mean the diameter or the circumference?

Where does the pipe come from into the basement? If you could trace it underground, with what would you find it connected?

Explanation. No matter what kind of drinking fountain you examine, you will find it has an opening for the water, a water-pipe, a basin to catch the water, and a drain pipe from this. Some fountains are so enclosed that you cannot see the pipes.

The faucet has a valve in it which closes the opening completely when you turn it in one direction and opens it when you turn it in the opposite direction. Some faucets have a spring arranged so that when you cease to press, the valve closes and stops the flow of water. This is called a spring faucet.

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you turn the faucet that it must be standing in the pipe ready to flow the moment it has a chance. In the basement you found the water-pipe coming in from the ground. If you could trace this outward, you would find it extending to the street where it is connected with a large pipe. The large pipes are called water mains. The size depends upon the amount of water needed by the people living along the street. In large cities they are much larger than in small towns. They vary from eight inches to two or three feet in diameter.

If you follow the main you finally come to a stand-pipe or a reservoir and a pumping station, usually near the source of the water supply.

Visit the pumping station and have the man in charge show you the pumps and explain their use. You may find one pumping water into the reservoir, another pumping it into mains or a stand-pipe. Visit the reservoir if possible. Get its dimension and determine how much water it will hold. Study also the stand-pipe. How high is it? What is its function? Can you make a piece of apparatus that will show the principle of the stand-pipe?

The force with which the water pours out of a faucet may be due to the pump at the pumping station or to the stand-pipe. Often the water is pumped directly into the mains. The pressure of the

persistent flow coming from the pump forces the water along through the mains and up into the pipes. The force from the stand-pipe is due to the pressure of the water itself. The stand-pipe is connected with the mains, and when it is full the pressure is sufficient to force the water into the pipes. Some force is lost by friction as the water flows along, so the highest faucet in the water system can not be quite as high as the water in the stand-pipe.

Where does the water come from that is pumped into the reservoir or stand-pipe? If the water is obtained from a river, find out how far away the river is and how the water gets from the river into the reservoir. If the source is a lake make the same investigation. How far out from the shore is the water procured?

Wells. If you live where wells supply the water, find out how many kinds of wells there are in your district. Study the well on the school grounds. Is it a drilled or dug well? How many people in the community use water from dug wells? What is the average depth of these wells? The diameter? With what are they walled up? Does the water level in them vary from time to time? Locate wells that go dry in the summer? Explain why.

How many drilled wells are there in the community? Find out how deep some of these are.

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How many drilled wells are there in the community? Find out how deep some of these are.

What is their diameter? Are there any artesian or flowing wells?

Experiment. What is the source of water in shallow or dug wells?

Into a shallow pan put a layer of soil or sand. About half way from the center make a hole similar to a dug well and wall it up with pebbles or bits of rock. Continue filling in soil and walling up the well till the pan is well filled. The soil should slope toward the part of the pan in which the well is located. Now pour water over the surface. When the water disappears put on some more. Continue till the soil seems well saturated. Watch the well and describe what takes place. Determine whether or not water comes into the well from all sides. To what extent does the slope affect the amount of water that flows into the well?

If this were a real well and the soil in the pan were a plot of ground where you were to build a home with a barn and all other buildings, where would you place the house? The other buildings? Where the well? Why?

Explanation. Your experiment shows the simple principle by which shallow, dug wells are supplied with water. The rain that falls upon the ground percolates or moves slowly downward. If there is a slope the water accumulates in the lowest places.

When a well is dug the water in the ground flows into the hole from all sides just as it did in the experiment. The higher the water stands in the surrounding soil the higher it stands in the well. The line which marks the upper surface of the water is called the ground water level. During dry weather this level may sink below the bottom of the well and then the well becomes dry.

Wells should be placed in relation to barns and other buildings so that water from around these will not flow into the wells. It is often safer to dig wells in the higher ground where they must necessarily be made deeper.

Experiment. What is the source of the water in deep, drilled wells?

Procure a large pan; a wide granite dish pan will serve. Put a sloping layer of cement in the bottom. To make the cement, mix together Portland cement, sand and water in the proportion 1/3 cement, 2/3 sand. On this place a sloping layer of sand, then another layer of cement. This should not cover the last three or four inches of sand in the highest part. Place a layer of soil over this. Insert a glass tube into the lowest part of the sand layer. Do this before you put on the top layer of cement. This represents a drilled well. Firm the cement closely around the tube and also around the sides of the pan. Pour

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water on the sand. Watch the well. How high does the water stand in it? Can any water from the layer of top soil get into it? Why?

Springs. To what extent do springs furnish water in the region where you live? Describe a spring if there is one near by. Is the water cool or warm? Does it flow constantly? Is the region level or hilly? Are there any rivers or creeks near by? How do you account for springs?

Explanation. If your experiment worked properly, you have a clear illustration of how water is supplied in drilled wells. The different layers of soil in the pan represent an area on the earth's surface where there is a layer of sand between two impervious layers of material such as solid rock or fine clay. The sand layer comes to the surface many miles away from the spot where the well is drilled. Rain falling upon this sinks down into the sand and moves slowly down the slope. Since there is an impervious layer under the sand the water cannot move farther down, so the sand becomes saturated with water and forms a vein. When the well is drilled through the upper layer into this the water in the vein rises through the open bottom of the pipe and stands as high as the water extends into the sand layer. No water from the soil near the well can enter through the iron pipe. It cannot reach the sand

layer which supplies the water because of the impervious layer on top of the sand.

Springs are due to precisely the same conditions as those described above except that the water makes its way to the surface and flows out.

Water and health. Which of the systems that you have studied is likely to supply the purest water? Why?

Water may have several different kinds of impurities in it: 1. It may have sediment which consists of small particles of sand, clay or bits of decaying matter. Most of this will settle to the bottom of a vessel in which the water stands quiet for some time. River water is likely to contain more sediment than lake or well water.

2. The second kind of impurity is dissolved mineral compounds of various kinds. Perhaps you have drunk water from springs that contained a vast amount of sulphur or other substance. This kind of impurity does not as a rule make water unhealthful. In fact, some waters are regarded very healthful because of the minerals dissolved in them. Most well water has considerable lime dissolved in it.

3. The third kind of impurity consists of living organisms in the water. Certain kinds of green plants called algae sometimes grow on the walls of reservoirs or even in the water. They are not in them-

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3. The third kind of impurity consists of living organisms in the water. Certain kinds of green plants called algae sometimes grow on the walls of reservoirs or even in the water. They are not in them-

selves harmful. The living organisms that are to be feared are bacteria, since they may produce human diseases. Chief among these is the typhoid fever germ. Statistics show that the spread of typhoid fever is largely through drinking water. This means that the germs from some one who is ill with typhoid get into the water supply. If the supply is taken from a river, it sometimes happens that the water is contaminated several miles above the place from which water is taken. You can see how easily this might happen since the water is constantly moving down-stream.

The same thing may happen when the supply is from a lake. The bacteria may be carried into the lake by drains or streams. If the water supply is taken from too near the shore, some of the bacteria may be distributed over the city in the water.

Shallow dug wells have bacteria carried into them with the water that flows near barns, outhouses and other places where there is waste material with germs in it. Typhoid fever is sometimes called a country disease, since there are in proportion more deaths due to this dread disease in the country and small towns than in cities. The reason, of course, is that in recent years more attention has been given in cities to securing pure water.

How to secure pure water. The drilled well sup-

plying water from a great depth is usually free from all disease germs. The water percolates so far through the beds of sand or gravel that any bacteria which may have been in it are killed. The deep well then, where it is possible to secure water in this way, solves the problem of pure water in the country and small town. Deep wells are used as the source of city water supply in many good-sized towns of the Middle West.

Spring water is usually pure for the same reason that deep well water is. Occasionally, however, spring water is contaminated by flowing through bacteria laden soil as it nears the surface where it flows out.

The dug well and pure water. The dug well should be placed so that water from feed lots, barns and outhouses may not readily drain into it. The last five or six feet of a deep dug well may be finished with a layer of cement over the brick wall. This prevents the ground water near the surface from entering. The cement wall should extend five or six inches above the surface of the ground and should have a tight cover so that no impurities may enter the well from the top. A deep dug well often reaches a layer of saturated sand, a vein, which supplies pure water.

Lakes and rivers. Cities that use lake water

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usually get their supply from deep water near the center of the lake. This is accomplished by making tunnels in the bottom of the lake extending out several miles. In some cases the water is filtered through beds of sand. When contamination is feared, chemicals are used in the water to kill the bacteria.

River water is filtered in most places. The beneficial results that come from attention to purifying the water supply can not longer be questioned.

Sewage. How to dispose of sewage is a problem that always goes along with the question of pure water. If you studied a drinking fountain or faucet, you found that the water from the basin or sink disappeared in a waste-pipe. If you could trace this pipe, you would find it connected with a sewer which opens into a large street sewer. Do you know where the sewers of your town discharge their contents? In many places the sewage is discharged into streams or lakes. From what we have already said you can see that there are many objections to this. Probably the time will come when this method, except perhaps in the largest cities, will be abandoned. Many small cities are installing septic tanks. The tank is a large receptacle of two or three compartments which receives the sewage. It is made of cement so it is absolutely water tight. Bacteria act upon the material changing it to gases and liquids until most of it

is disposed of. The small amount of solid matter known as sludge is occasionally removed from the tanks and used as a fertilizer.

The need of water. The human body is composed of different organs all of which are built up of tissues. There are then several different kinds of tissue in the body.

Muscle tissue composes the flesh and makes movements possible.

Skin tissue, also called epithelium, makes the outside covering of the body as well as the lining of the mouth and other inner parts.

Connective tissue is a membrane that helps to hold together the different parts of the body, as the bundles of muscle fibers.

Nerve tissue makes up the brain and nerves.

Fat is a tissue found in various organs. It usually stores up material for future use.

Gland tissue composes certain organs which make secretions for use in the body as the saliva in the mouth and the digestive fluids in the stomach.

Bone and cartilage tissue are the solid, supporting parts of the body.

Now all of these tissues are made up of cells so small that you would need a microscope to see them. Each cell is made of a substance called protoplasm, and this is composed in large part of water, so that

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the very material of which the body is composed is dependent upon water. About three-fourths of the muscles are water, nine-tenths of the blood and nearly one-half of the bones and cartilage.

Besides forming a part of the cells and tissues, water is needed to soften all solid foods that you eat, for they must be dissolved and liquefied before they can be taken into the blood. Without sufficient water in the alimentary canal the food moves along with difficulty and indigestion is likely to follow.

Oxidation is a process of "burning" which occurs in the body when the oxygen we breathe combines with the food we eat. The result of oxidation is heat and energy for the body.

In the process of oxidation in the cells of the body waste products are produced. These must be dissolved in the watery part of the blood and carried to the organs that throw them out of the body as waste matter. Hence the blood must have a constant supply of water. The chief avenues by which water with waste material is given out of the body are through the skin by perspiration, through the lungs, and by way of kidneys. The amount given off through the skin by the average healthy person should be two pints each day, from the lungs one pint, and through the kidneys three pints.

An important function of the water taken into the

body is to flush out the system. It takes out the waste materials which otherwise develop poisons.

The facts given above suggest that if you wish to keep well you must drink plenty of water. An adult should drink about two quarts of water a day. A habit of drinking a glass of water upon rising and one just before retiring is most valuable. Many of the best physicians claim that no harm comes from drinking as much as you desire while eating.

If there is any question as to whether water is pure it should be sterilized. This is done by bringing water to the boiling point, allowing it to boil a few minutes and then letting it cool. When cool boil it a second time, put in jars or bottles, keep in the ice box or other cool place. The second boiling kills any of bacteria that may have escaped the first time.

Water and care of skin. Water is needed to keep the skin in healthy condition. The small openings from the sweat glands must be kept open in order that there may be a free flow of perspiration all the time. These may become clogged with bits of solid matter that are left after the sweat evaporates. Then the oil glands connected with the roots of the hairs pour out on the skin a small amount of oil. This holds bits of dust and may clog the sweat glands. Bathing is necessary to keep the pores open and active. How often one needs to bathe depends upon the individual,

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but everyone should bathe often enough to keep the skin perfectly clean.

Cleanliness is not the only reason for bathing frequently. A bath stimulates the skin and in a way the whole body. Some people find that a cold bath in the morning invigorates them for the entire day. Delicate persons sometimes find that the cold bath is too stimulating to the heart. A cold bath should leave one with a warm glow all over the body. This is brought about in part by vigorous rubbing after leaving the bath. Just after rising is the best time for a cold bath, or when one is sweating and the body is very warm, though one should use care not to stay in the cold bath too long; one, two or three minutes is usually sufficient.

A hot bath with soap is necessary to thoroughly cleanse the skin. Hot baths should not be taken in cold weather if one goes out-of-doors soon afterward. The application of heat to the skin causes the pores to open and the blood to flow to the surface. While in this condition the body can offer little resistance to the cold, so you can see why it is a dangerous thing to go out-of-doors after taking a hot bath before the skin has had time to recover its normal condition. Just before going to bed is the best time for a hot bath.

CHAPTER XXI

FORMS OF WATER

Material. Several tin cups, a small glass bottle; a flask with a side delivery tube, or a rubber stopper with a tube inserted in it; a measuring cup or graduate; shallow pans, and a thermometer.

In the last chapter you found out a number of facts about water as a liquid. But water exists in other forms that are quite as interesting.

Experiment. Some facts about ice.

(a) Fill a small glass bottle with water and put in a stopper. Set this in a dish and put it out-of-doors over night when the weather is very cold.

(b) Fill a tin cup level full of water, set in a dish and place out-of-doors under similar conditions.

Examine both bottle and cup the next morning. What do you find? How do you account for the broken bottle? What evidence have you that the bottle broke before all the water was frozen? What has happened to the tin cup? Is it level full of ice? Which occupies more space, water or ice?

Explanation. Ice, of course, is water in a solid form. There is a definite point of temperature at which

water begins to solidify. When it cools down to within a few degrees of freezing it begins to expand, so it must occupy more space. The point at which cooling water begins to expand is 39° F. or 4° C. That is why the ice bulges up in the tin cup. The force of the expanding water broke the bottle. The fact that you found some water frozen in the dish tells you that all the water had not solidified when the bottle broke. Sometimes the force of the expanding water pushes the stopper out of the bottle instead of breaking the glass.

Since water expands as it freezes, which do you think is heavier, ice or water?

Experiment. Comparative weight of ice and water. Put a chunk of ice at least two inches thick into a deep pan of water. Does it sink or float? How much of it sinks down into the water? If it were heavier than water, what would it do? What would it do if it were just the same weight as water? If ice were heavier than water, what would happen when it forms on lakes and streams?

Make a list of all the uses of ice. How is ice kept for use during hot weather? If possible, visit an ice house and see for yourself how it is stored and kept.

Explanation. You can readily see that to keep ice during the summer months the temperature of the ice house must not go higher than the melting point

of ice. To keep it at this low temperature the house is constructed in a way to keep out the heat. That is, non-conductors are used to prevent heat from entering the house.

Experiments. Water vapor. (a) Put some water into a tin cup or pan and measure the exact depth with your ruler. Set the pan in a warm place on the radiator, near the register, or on the stove. After a few hours measure the water. Leave it in the warm place for twenty-four hours and then examine it again. What has become of the water?

(b) Take a flask having a long delivery tube and pour in water until it is about half-full. Put in a stopper. Heat the water, watching it carefully and noting everything that happens. When the water is boiling briskly what is taking place at the delivery tube? Look closely at the mouth of the tube and compare what you find there with what is seen a little farther out. Look in the space above the water in the flask. Can you see anything? What must be in this space? What is your conclusion as to whether water vapor is visible or invisible?

(c) Hold a dry, cold tin cup for several minutes at the mouth of the tube so that the vapor will enter the cup. What happens?

Explanation. The water which was in the tin cup disappeared because the heat changed it from a liquid

into a vapor. The vapor went off into the air and you did not see it. When any liquid changes into a vapor we say that it evaporates.

The same thing took place in the flask, but because more heat was applied to it the evaporation took place more rapidly. Some of it changed into vapor near the bottom of the flask and formed large bubbles which came to the surface of the water and broke. This process we call boiling.

The space above the boiling water and at the mouth of the delivery tube seemed empty because water vapor is invisible. What then is the steam that you saw a little farther out from the tube? Your second experiment probably helped you to solve that problem. When you allowed the vapor to enter the tin cup it was changed back into water. The steam that you saw was vapor changing into water. At first the water drops are so tiny that they float in the air making the cloud of steam. When water boils and changes rapidly into vapor we sometimes call the process vaporization instead of evaporation. The process by which vapor is changed back into water is called condensation.

Experiments. What conditions influence the evaporation of liquids?

(a) Measure or weigh an exact amount of water and put it into a shallow pan. Put the same amount

into a pint cup and into a pickle bottle. Set the three side by side. The next day measure or weigh the amount left in each. From which has the greatest amount of water evaporated? The least? How do you account for the difference?

(b) Put equal amounts of water into two tin cups or tumblers of exactly the same shape and size. Put one in a warm, the other in a cool place. After twenty-four hours measure the water in each and account for the difference.

(c) Place equal amounts of water in two tin cups. Set them side by side where there is a draft of air. If it is not freezing weather set them out-of-doors. Cover one cup closely with a saucer or another cup. Leave the other open. Measure the water the next day and explain the difference.

Explanation. Your experiments show the following truths:

1. Water evaporates more rapidly from a large exposed surface than from a small one.

2. The higher the temperature the more rapid the evaporation.

3. Evaporation is more rapid when air moves over the surface of the water.

You may call these the laws of evaporation. They are just as true of other liquids as of water. All liquids, however, do not evaporate at the same rate.

You can prove this by putting the same amount each of water, milk and alcohol into cups and allowing them to stand for a number of hours, then noting what is left of each.

Make a list of all the applications and illustrations of the laws of evaporation that you can think of.

Experiment. What is the effect of evaporation upon surrounding bodies?

(a) Dip your finger into water and then rub it on the back of your hand. Hold your hand up in the air waving it gently. How does the wet spot feel? Touch your hand in the same way with alcohol. What happened to the water and alcohol?

(b) Dip the bulb of a thermometer into water or alcohol. Wave it gently back and forth till the liquid has all evaporated. Does the mercury rise or fall? What is your answer to the question at the beginning of this experiment? Why do you feel chilly when you sit in damp clothing? Why does sprinkling the street on a hot summer day cool the air?

Explanation. When a liquid is changed into a vapor heat is used in producing the change. The water and alcohol used or absorbed some of the heat from your hand in evaporating or changing to a vapor and your hand felt cool. The heat of your body is used to evaporate the water from damp clothing. In the same way the thermometer was cooled by the evapora-

tion of the liquid and the mercury went down. To state it briefly, you may say: Evaporation has a cooling effect upon surrounding bodies.

Artificial ice. The manufacture of artificial ice is dependent upon the law you have just discovered. The ice plant has a number of parts, but the part in which the ice is made is a huge tank filled with brine through which a coil of pipes extends. Sitting in the brine are rectangular cans filled with pure water and

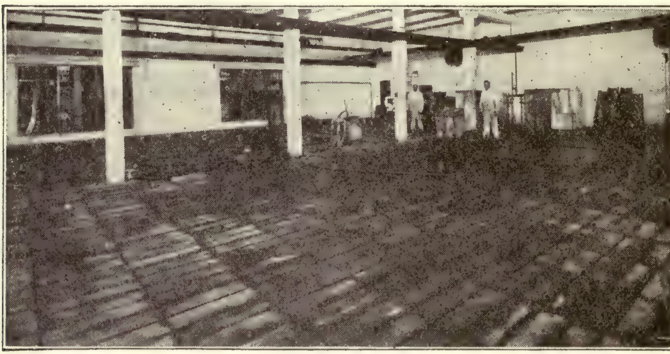


Fig. 66. Interior of tank room in an ice factory. The brine tank and the ammonia coils are under the floor.

tightly closed. At just the right moment a valve is opened allowing liquid ammonia to enter the pipes. The ammonia at once changes to vapor or gas so rapidly that it absorbs a vast amount of heat from the brine. The brine in turn absorbs heat from the water in the cans. This process continues until the water is frozen.

The regulation of heat in the human body. The last experiment will help you to understand how the heat of your own body is kept regular. You probably know that a person who is in good health has a normal temperature of about 98° F. The heat of the body is produced by oxidation in the cells. The heat is regulated in two ways.

1. By the perspiration, which is poured out upon the surface of the skin. The heat of the body evaporates this moisture and thus the body is cooled. The warmer the temperature the more rapid is the flow of perspiration and the more heat is used in its evaporation, hence the body temperature is kept from rising when one perspires. Some moisture is constantly being given off through the skin even though it is not noticeable.

2. The body heat is also regulated by the loss of heat due to the fact that the air surrounding the body is usually cooler than the body. The skin radiates heat and the blood near the surface becomes cool and flows toward the interior of the body, while warmer blood takes its place. The more rapidly the warm blood flows through the skin the more heat will be lost in a given time.

Heat of vaporization. The heat that is used in vaporizing liquids is called the heat of vaporization. This heat does not affect temperature.

Experiment. Fill a tin cup or glass flask half full of cold water. Set it over an alcohol lamp. Hold a thermometer in the water, do not let it touch the bottom, and watch the mercury. How high does it rise? What temperature is indicated when the water boils? Keep the thermometer in the boiling water several minutes or until you are sure that the mercury is not changing its position. Why does not the heat that is passing into the water continue to make it hotter?

The heat at first was used in changing the temperature. When the water began to boil all the heat was used in changing the water into vapor. An interesting fact about this heat of vaporization is that when the vapor changes back to water or condenses it gives out as much heat as was used in changing it into vapor. This explains how steam from a boiler heats a radiator. The vapor or steam enters the radiator, cools and changes back to water. In this process it gives out all the heat that was used in vaporizing it, and thus heats the radiator.

Water vapor in air. Is there any water vapor in the air of your school room or home? How do you know? Think of the frost that gathers on the windows on a cold night or the moisture that gathers on the outside of a pitcher on a warm summer day.

Is there water vapor in the air out-of-doors? Where

does it come from? How are clouds formed? What causes rain? Snow?

Evaporation is constantly taking place from all bodies and streams of water as well as from the soil. When air is warm it can hold a great deal of vapor. When a mass of air is cooled the vapor begins to condense and form clouds, just as it did from the tube of the flask. If it is cooled still more, the tiny drops unite and form larger ones. Presently they become so large that they can no longer float in the air. They fall and we have a shower of rain.

Sometimes the vapor becomes so cold that it freezes or forms crystals before it is condensed into water. Then it falls in the form of snow. When there is a light, fine snow catch some of the crystals on a piece of dark cloth or your coat sleeve and study their shape. How many different forms do you find? Snow flakes are composed of great masses of the six-pointed star crystals.

CHAPTER XXII

HEAT AND HEATING

Material. The heating plants of the school and home; candles; alcohol lamp or Bunsen burner; other simple pieces of apparatus suggested in connection with experiments.

Heating of the school building. How is your school room heated? Look around until you find the source of the heat. You may find a stove, a hot air register, or a steam radiator.

Experiment. Study of air currents in connection with the source of heat. Make a very fine fringe of tissue paper about eight or nine inches long and an inch or two wide. Fasten this to a long stick by means of a rubber band or paste. A lighted candle or piece of smoking punk will give more definite results. Hold the fringed paper or candle close to the register. What happens? Try it in various positions. Hold it close to the ceiling in the vicinity of the register. Try it in various parts of the room. What causes it to move? What direction are the air currents moving with reference to the register?

If there is another register in the room, make the same tests. Is the air coming in or going out of this

one? Decide which is the hot and which is the cold air register. If you have a stove or steam radiator in the room, try the same experiments with them. Hold the fringed paper or candle above them, at the sides, near the top, near the floor. Hold it in the vicinity of windows and doors. Open a door about twelve inches; hold the candle first near the top of the opening. Slowly move it downward. How do you account for what takes place? Try the same experiment at home; first with a door opening into another room; second with one opening out-of-doors.

Explanation. Your experiments have shown you that there are movements of air in the room. The warm air is moving in one direction, the cooler air is moving in the opposite direction. The warm air moves toward the upper part of the room, spreads out in all directions, and then as it cools slowly moves downward.

Experiments. Do you find movements of air around any heated body?

Light a piece of a candle about four or five inches tall. Cut a strip of blotting paper about half an inch wide, or use punk. Light it, then blow out the flame and hold it so that the smoke may move with the air currents around the burning candle. Does the smoke move toward or away from the flame? What is the movement above the flame? Where is

the air about the candle the hottest? Does the cool air move toward or away from the heat of the candle?

Explanation. Currents of air due to unequal heating are called convection currents. Why does the air move? Before you try to solve this problem, make a study of the source of heat. If you trace to its source the hot air that comes into the room through the register, you will find it starts from a furnace or a heated room in the basement, and is carried upward through a pipe in the wall that finally opens into the register.

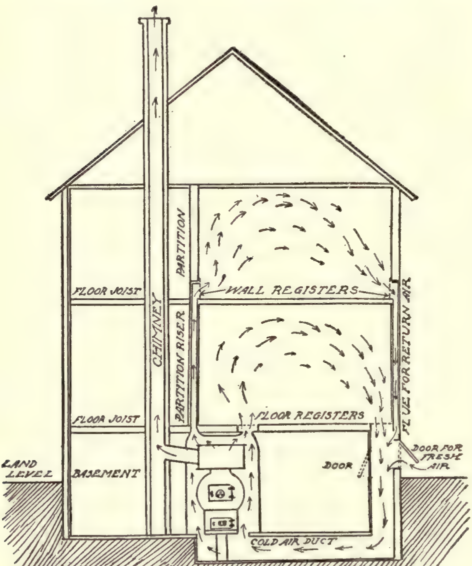


Fig. 67. Convection currents from a hot air furnace. (After Barber.)

The hot air furnace. Make a careful study of the furnace. Write the names of all the parts and try to determine their uses. If you have a furnace at home, study it and report what you find.

How large is the fire pot? What is the distance

from the outside of the jacket to the inside of the furnace? What provision is made for air to enter the jacket? How many cold air ducts are there? Where do they enter the jacket? How many hot air ducts are there? To what part of the jacket are they attached? Investigate carefully to see whether there is any chance for air from the basement to get into the jacket. Find the air duct that leaves the furnace and goes to your room. If you are studying your home furnace, find the ducts leading to the various rooms. Trace the cool air ducts to the source of fresh air. Where do you find them? Do they get their supply of cool air from the outside or the inside of the building? Where are the cold air registers in your home? Trace the convection current from the jacket to your room and back to the furnace. What provision is made in your home to purify the air before it returns to the furnace?

In a large school building you may find that the heated air comes from a room in the basement instead of from a jacket. In this kind of a heating plant you will find openings from out-of-doors into the basement. The pure cold air passes over a number of hot steam pipes; then by means of fans it is forced into a large room. From this room the hot air ducts carry it to the various rooms of the build-

ing. With such a system you will find that the cool, impure air passes out of the building through ducts arranged for this purpose. You can see these openings like small chimneys on the top of the building.

In homes heated by hot air furnaces, the cold air registers are frequently placed in the front hall, sometimes in the dining or the living rooms near a window. How is fresh air supplied when this is the case?

Jacketed stove. If your school room is heated by a jacketed stove, study its parts as suggested for the furnace. Find the duct for the entrance of cool air to the jacket, the one for warm air to leave the jacket.

How wide is the air space between the jacket and fire bowl? What provision do you find for the escape of impure air? Test with a thermometer different parts of the room and decide whether or not a jacketed stove heats the entire room evenly.

If you have an ordinary heating stove, trace the convection currents from this to all parts of the room. Also test the temperature in different parts.

Experiments. What causes convection currents of air?

1. Stand a thermometer on the floor of the room for several minutes and take the reading. Now place it high up in the room, let it remain a while and take

the reading. Which position shows the highest temperature?

2. Into a small portion of hot water put a few drops of red ink. Fill a tumbler half full of very cold water. With a common dropper or fountain pen filler put some of the hot red water into the bottom of the glass of cold water. What does it do?

3. Hold a small piece of wood or cork in the bottom of a glass of water. Remove your fingers. What happens?

Why did the piece of wood come to the top of the water? Why did the warm water come to the top and float on the cold water? Why is the warmest air at the top of the room? The next experiment will help to answer these questions.

4. Tie a piece of sheet rubber very securely over the top of a flask. Now heat the flask. Why does the rubber bulge upward? What is in the flask? You can show the same principle by another experiment. Hold the mouth of an open flask under water. With an alcohol or gas lamp heat the flask. Why do bubbles of air come out into the water?

Explanation. You no doubt see that the wood floats on the water, the warm water floats on the cold, and the warm air floats on the cool air because in each case the body that floats is lighter than the other one. Your experiments with the flask full of

air tell you that when air is heated it expands and occupies a larger space. In the first case it pushed the sheet rubber upward; in the second it came out of the flask into the water. If it expands or spreads out, any definite portion of it must, of course, become lighter.

When the air in the jacket of the furnace or stove is heated it expands, becomes lighter and the cold air below floats or pushes it upward, through the pipes or ducts and into the room. In the room the same thing occurs. The warm air is pushed upward; it cools and slowly drops down. There are then constant currents all over the room. This continues as long as some air is warm and light and some cool and heavy. The heavy air always moves toward the light air, floating or buoying it upward. The greater the difference in temperature the more rapid is the movement.

Convection currents in a chimney. What is the purpose of the draft at the lower front part of a stove or furnace? What causes the cold air to enter? Trace the convection current from the room through the stove and out at the chimney. Why does the opening of the check draft at the back of the furnace keep the fire from burning so rapidly? Why does closing the damper in the pipe have the same effect?

Explanation. When the fire begins to burn and

heat the air in the stove, the cold air below pushes in and the heated air with the smoke and gases from the burning fuel are pushed up the chimney. There must be a fresh supply of air in the stove or there can be no fire, so this movement of convection currents up the chimney helps to keep the fire burning. When you close the draft below you shut out a part of the air supply, so the fire cannot burn so rapidly. At the same time you lessen the movement up the chimney. When you open the check draft the cold air rushes in and cools the air in the pipe and chimney, thus causing the convection current to move more slowly.

If the lower part of the furnace or stove becomes clogged with ashes, this cuts off the supply of fresh air to the fuel and retards the burning.

Convection currents and wind. Have you ever stood near a bonfire and watched the strong current carry light bits of materials upward? And have you felt the cold air rushing around you toward the fire? If you can explain the reason for this strong movement of air toward the fire, then you understand pretty well the cause of all winds on the earth's surface from a light breeze to a raging tornado. If any area on the earth's surface becomes heated more than the surrounding areas, what will be the effect upon the air? Will the air move away from or toward

the heated area? The greater the difference in temperature between the two areas, the more rapidly will the wind blow. Since the difference of temperature really causes differences in weight and pressure of the air, we usually call the area of light air a low pressure region, and the area of heavy air a high pressure one. The wind always blows toward the light or low pressure region.

Fuels. Make a list of all the different kinds of fuel that you know. What is used in your home for heating purposes, for cooking? By reference to your geography locate the chief anthracite or hard-coal fields; the bituminous or soft coal fields; regions where wood is still used. Make a comparative study of the prices of different kinds of fuel.

Experiments. How fuels burn. Look into a furnace or stove and watch the burning of the fuel. What do you see happening?

Take a small splinter from a pine board. It should be eight or nine inches long and not less than half an inch wide. A pointed piece split from a lath is good for this experiment. Hold the end of it in a candle flame till it begins to burn. Watch it burn a few moments, then blow out the flame. What continues to come from the wood? Put a lighted match in the smoke. What happens? Has the stick entirely ceased burning when the flame is extinguished? Blow

gently upon the glowing portion. Does it burn more or less brightly? Which burns more closely to the wood, the flame or the glow? What changes take place in the color of the wood as it burns? What is left after the black portion is burned?

Explanation. At first the wood burned with a flame. When you extinguished the flame by blowing upon it, you found that the stick still smoked, and by applying a match you could start the flame again. The smoke is made up of gases from the wood that burn with a flame. The black portion that is left after the gases are burned is charcoal. Charcoal is nearly all carbon. The solid carbon burns with a glow and gives out much heat. The white part that is left after the charcoal burns is called ash or ashes and is composed of minerals that will not burn. If you apply these observations to the coal or wood in the stove or furnace, you find exactly the same thing happening. The gases burn with a flame, the solid carbon, charcoal in wood, coke in coal, burn with a glow.

Experiments. What is needed besides fuel to produce burning?

1. Light a fresh splinter of wood and when it is burning brightly thrust it into a tumbler. Hold both tumbler and splinter sideways. Does it burn as long as when you hold it out in the air?

2. Light a candle that is about two inches high, set it on the table and turn a tumbler over it. Why does the flame go out?

These simple experiments show that you can not burn any material without air. In fact, burning is a chemical process. When you held the splinter of wood in the flame, it became heated and a portion of it was changed into gas or smoke. When there was enough of this heated gas, the oxygen of the air began to unite with it. This union is called combustion, or, in everyday terms, burning. The parts of the wood and the oxygen unite and form new substances that go off into the air of the room. When the gas is all burned out of the wood, the solid carbon is left and the oxygen continues to unite with it. This union is accompanied by a glow instead of a flame. Oxygen will not unite with the minerals, so when the burning ceases the ash is left. Whenever anything is burning then, it means that oxygen is uniting with it and is forming a new substance. One of the substances formed is carbon dioxide, of which you will learn more in the next chapter.

Like all the other elements of the air, oxygen is invisible. Nevertheless, you can find out something about it by an experiment.

Experiment. How to make oxygen. Mix together equal portions of crushed potassium chlorate and

manganese dioxide. Put two or three spoonfuls into a test tube. Place a stopper in the open end with a tube passing through it. Fill a few jars or bottles with water and invert them in a pan of water. Now heat the substance for a few minutes, and place the end of the rubber tube into one of the inverted bottles. Note what takes place. When all the water has been driven out, insert the tube into another bottle. Continue this until all the bottles are filled with oxygen.

Explanation. You have been generating oxygen. Potassium chlorate is a compound made of three

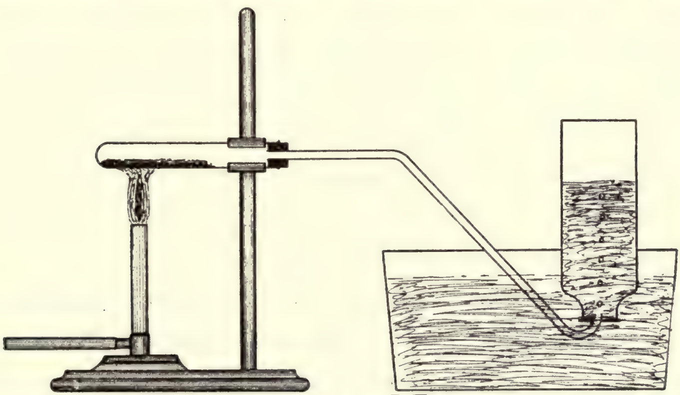


Fig. 68. Apparatus for making oxygen.

different elements united into one substance. These are oxygen, potassium, and chlorine. When you applied heat the compound was decomposed or broken up. The oxygen was set free and escaped through

the tube. The manganese dioxide was put in to help set the oxygen free at a low temperature. That is, without it you would have to make the potassium chlorate much hotter to release the oxygen. The oxygen passed through the tube up into the bottle of water. As it is lighter than water it went to the top, and as it filled the bottle the water was forced out.

How oxygen behaves. Light a splinter of wood, allow it to burn a minute. Note the size and color of the flame. Now, invert one of the bottles containing oxygen and insert the burning splinter into it. What change takes place in the burning? Light another splinter and allow it to burn a moment. Then blow out the flame. Insert the glowing splinter into a bottle of oxygen. What happens? Twist a piece of wire around a small bit of charcoal. Set the charcoal on fire, then lower it into a bottle of oxygen. Do the same with a candle.

All these experiments tell you that burning or combustion takes place much more rapidly in oxygen than in air. What really happens is that the oxygen unites with the elements of the wood producing at the same time flame and heat. The chief element in wood is carbon, and the chief compound formed by the union of oxygen and wood is carbon dioxide.

Experiment. Conduction of heat. Put the end of

an iron rod or poker into a fire or the flame of an alcohol lamp. Remove it after several minutes. How far from the point where it was surrounded by the fire can you detect heat? What must have taken place in the iron? Think of other illustrations which show that heat seems to travel slowly through a body. Think of materials that do not allow heat to move readily through them in this way. If you should place a rod of wood in the fire instead of iron, what would happen? What is the value of wooden handles on cooking utensils? Why is woolen cloth or fur warmer than cotton or linen?

Explanation. A substance like iron that permits heat to move rapidly through it from one little particle to another is called a conductor of heat. Most metals are good conductors. Wood is a non-conductor. It may be hot enough to burn and yet be cool a few inches from the flame.

Certain kinds of cloth are excellent non-conductors of heat. Since your body produces its own heat, your clothing keeps you warm because it prevents the heat from passing off into the air. Wool and fur are better non-conductors than cotton. Linen is cooler than any of the others because it is a better conductor. Air is one of the best non-conductors. It is really the air among the fibers of wool and fur that makes them such excellent non-conductors.

The fireless cooker. The fireless cooker is a practical application of the principle of non-conduction. You may make one of these cookers with very little expense. Procure a large tin coffee bucket and another one three or four inches less in diameter. Both should have close fitting lids. Cover the small pail all over including the lid with two layers of asbestos paper. Line the large pail with the same material. Put a packing three or four inches deep of excelsior in the bottom of the large pail and set the small pail upon this. Now fill in the space between the two pails with excelsior, pushing it down firmly. Newspapers torn to shreds may be used instead. Foods such as rice, breakfast foods, beans and meats, may be cooked by first heating them to the boiling point, or, in the case of meat and beans, cooking for about fifteen or twenty minutes, then plac-

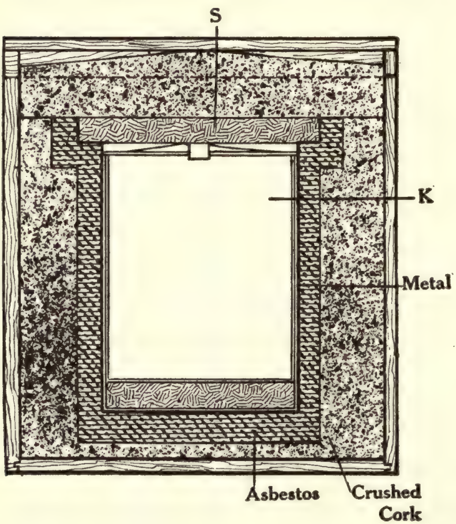


Fig. 69. Section of a fireless cooker. s. Soapstone; k. Kettle.

ing the warm kettle or pan in the cooker. Cover quickly and allow to stand from three to five hours or all night. The non-conducting substances, asbestos and excelsior, retain the heat and the food slowly cooks. Two boxes may be used instead of tin pails.

Experiment. Radiant heat. Heat the end of an iron rod or poker very hot. Now hold your hand near the heated portion, first beneath, then on the sides, then above, and determine whether or not you can feel heat coming from it in all directions. The heat that is given off in straight lines from any heated body is called radiant heat. Every heated body gives out radiant heat equally in all directions. An ordinary heating stove or a steam radiator heats the room in two ways: 1. It heats the air around it, which you have found causes convection currents that carry the heat through the room. 2. It sends out radiant heat in all directions. For this reason objects in the room nearest the source of heat become much warmer than those farther away. You may have observed that steam and hot water radiators are placed in the coldest part of the room so that the heated air will move rapidly to all other parts.

The heat that comes from the sun is radiant heat. The earth absorbs it and becomes warm, then it in turn, especially at night and in winter, cools by radiating its heat into the air.

Measuring temperature. What instrument do you use to determine the temperature of a room or any body? Examine a thermometer. Name everything that you find. What is the highest number of the scale? The lowest? How many degrees apart are the lines of the scale? What degree is marked "Freezing"? What is the name of the thermometer? You may find instead of the name the letter F or C. The former stands for Fahrenheit; the latter for Centigrade. The Fahrenheit scale has 180 degrees between the freezing point and the boiling point; the Centigrade scale only 100 degrees.

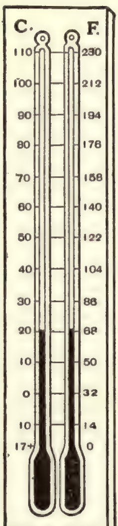


Fig. 70. A Centigrade and a Fahrenheit Thermometer.

Put the bulb into a dish of melting ice or snow and watch the mercury. Describe what happens. If it is a Fahrenheit thermometer and has a scale numbered as high as 212°, put the ice cold water into a tin cup and hold a thermometer in it. Now heat the water slowly until it boils. Do not let the thermometer rest on the bottom of the cup. Describe what happens. Why does the mercury change its position?

Experiment. Why does the mercury stop at a certain point in the melting ice, and at another definite point in boiling water?

Fill a flask with cold water, place in the flask a stopper with a small glass tube twelve or fifteen inches long passing through it. Push the stopper down until the water stands a short distance up in the tube. Now slowly heat the flask. What happens? When the water has almost reached the top of the tube, set the flask in a cold place and watch for results. How did heat affect the water? How did cold affect it?

Try the same experiment with some other liquids as alcohol, vinegar, or skimmed milk, and compare results.

Explanation. Your experiments show that water and other liquids expand when heated and contract when cooled. Most thermometers have the tube filled with mercury; some have alcohol. These liquids expand with heat and contract with the cold. Water could be used to make a thermometer, but since it freezes at a much higher temperature than mercury or alcohol, you can see that it would not be of much use.

You found in testing your thermometer that the melting point of ice or snow is zero on the Centigrade and thirty-two on the Fahrenheit. Water freezes at the same temperature that ice melts. When a pan of ice is melting the temperature remains at 32° F. or 0° C. until all the ice is melted. Zero on

the Fahrenheit scale marks the temperature at which a mixture of salt and ice freezes.

You found that water boiled at something below 212° F. or 100° C., and as long as you kept the thermometer in the boiling water it did not go any higher. At sea level the boiling point of water is exactly 212° F. and 100° C. That shows that no matter how much heat you put into water after it begins to boil, it does not get any hotter. What does this heat do?

The refrigerator. Examine a refrigerator. How many distinct parts has it? Of what material is the outside made? The inside? How wide a space is there between the outside and the inside wall? What is the value of this space? Where is the ice placed, above or at the side of the food? How many openings do you find between the food compartment and the ice box? Hold a piece of smoking punk or paper-lighter both below and above these openings and determine the direction of the air currents. In what direction is the cold air moving from the ice? The warm air from the food? What causes the convection current? Test the temperature of the food compartment; of the ice box. Compare with outside temperature. In making the temperature test leave the thermometer several minutes in each compartment of the refrigerator with the doors all closed,

then read it quickly before you remove it from the compartment.

Explanation. The refrigerator illustrates several of the principles you have been studying. The space between the inner and outer wall is filled with some kind of non-conducting material that prevents some heat from entering the refrigerator. The air in the space is itself a poor conductor of heat. The thermometer told you that the air leaving the ice box is cooler than that in the food compartment. It moves downward at the central opening just under the ice, while the warmer air moves upward through the side openings. This warm air passes over the ice, is again cooled, and again drops down into the food compartment. The heat in the warm air is used to melt the ice. This is the chief reason that it cools so quickly.

Your refrigerator may have an opening at each side instead of one in the middle. In that case the cold air goes down one side and the warmer air up the other. Some refrigerators have the ice box at the side instead of at the top. The openings are arranged so that the cold air moves downward on the side toward the ice and upward on the other side.

Making ice cream. If you have ever made ice cream you know that ice and salt are placed in the freezer around the can that holds the cream. The

ice begins to melt and the salt dissolves and soon the cream is frozen. Ice in the process of melting or changing to water absorbs heat just as water changing to vapor does. In the freezer the melting ice uses up heat from the cream, but it probably would not cool it enough to freeze if it were not for the salt, which causes the ice to melt more rapidly. The temperature of a mixture of salt and ice is much lower than that of melting ice alone, as you have already discovered from your study of the Fahrenheit thermometer. The heat absorbed by the mixture soon cools the cream down to the freezing point.

CHAPTER XXIII

AIR

What air is. You can not study the heating of the home without at the same time giving some attention to air and ventilation. You have already found that heating buildings by any system depends largely upon air currents.

What is air? It is not easy to answer this question. In the first place, air is invisible. You cannot see it but you can feel it rushing against you when the wind blows, or when you run or ride rapidly. It fills every space on the earth that is not occupied by something else. If you pour water out of a pitcher, air immediately rushes in and fills up the space. When you say a cup, a box, or a bottle is empty, you really mean that it has nothing in it but air. Air fills the small spaces in the soil when they are not full of water. Even the water in streams, lakes, and the ocean has air mixed with it. If it were not for this, fish and other water animals could not exist. Air surrounds the entire earth like a great envelope, extending outward at least 100 miles, pos-

sibly more. We usually speak of this envelope of air as the atmosphere.

Air is a mixture of several gases. You know already what some of them are. You remember that the part of the air that unites with wood and other materials in burning is oxygen. This is the most important gas in the air. All animals and plants as well as fires are dependent upon it for existence. About twenty per cent of pure air is oxygen.

You have also found that there is water vapor in the air. It contains three other gases. Nitrogen constitutes nearly seventy-eight per cent of the entire bulk of air. Then there is some argon and a small amount of carbon dioxide. Beside the gases air always contains a great number of floating dust particles.

The proportion of the gases in the air varies from time to time, and the amount of water vapor varies greatly. There is always a much larger per cent preceding rainstorms.

The air that you exhale has more carbon dioxide and less oxygen than the air you inhale. Exhaled air contains about 4 per cent carbon dioxide and 16 per cent oxygen.

The different substances in pure air, with the approximate amount of each, is shown in the following table:

	Per cent. of volume
Nitrogen	77.42
Oxygen	20.77
Carbon dioxide	0.03
Argon and other gases	0.93
Water vapor	0.85
	100.00

Facts about air. There are some other facts concerning air that you can find out by experiment. You will need a tumbler, a tall wide-mouthed bottle, a tube about fifteen inches long with a stopper in one end; a tube five or six feet long; another of small diameter about thirty inches long.

Experiment 1. Fill the tumbler with water. Hold your hand over the mouth and invert the tumbler in a pan of water with the mouth just under the surface.

Experiment 2. Try the same experiment with the tall bottle and the long tube. What holds the water up in the vessels?

Experiment 3. Fill the 15-inch tube and invert as you did the tumbler and bottle. While you are holding it remove the stopper from the upper end. What happens? Why did the water flow out?

Explanation. The last experiment will help you to answer the question raised by the other two. When you removed the stopper the air above the tube

pushed the water down into the pan. The air is pushing with the same force upon the surface of the water in the pan. As long as the tube was closed at the top the air could not exert any direct force upon the water, so the pressure of the air upon the surface of the water in the pan held the column of water up in the tube. If this is true, then air must have weight. If you had an air-pump and a bottle with a stopcock, you could prove by experiment that this is true. Air does not weigh very much. A cubic foot of air weighs about 534 grains. But when a column of air several hundred feet high presses down upon the earth, or upon bodies on the earth, even this relatively light weight gives it considerable force or pressure. Scientists have found by experiment that the pressure of the air near the level of the sea is about 15 pounds per square inch.

Experiment 4. Do you think you could find a tube so long that the air pressure could not hold the water to the top of it? You can answer this question by using mercury instead of water. Fill the small tube full of mercury and invert it in a dish of mercury. What happens? Why did some of the mercury flow out? Why did it stop after a certain amount had flowed out? With a meter stick or yard ruler measure the height of the column of mercury in the tube. Since mercury is 13½ times as heavy as water,

how high a column of water would the air hold up? How high is the column of air that is balancing the column of mercury? Fasten the tube of mercury to the rod of a burette stand or some other support and allow it to stand in the room for a number of days. Measure the column twice every day. Can you explain why it varies? What name may you give to this simple instrument that enables you to measure air pressure?

Explanation. Some of the mercury flowed out of the tube into the dish because the air pressure was not sufficient to hold it all up. When the weight of the column of air and of the mercury were just the same the mercury ceased to flow out. You can think of the air and mercury columns as a pair of balances with the weight on each side exactly equal. The column of air has exactly the same cross-section area as that of the mercury, but it is as high as the air extends above the earth. See Fig. 65.

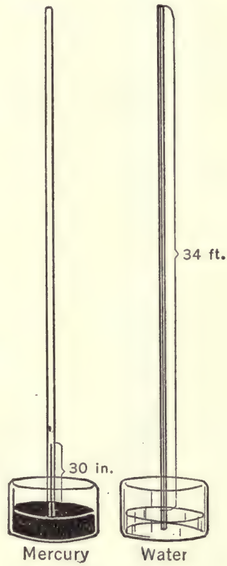


Fig. 71. Air supports a column of mercury 30 inches; a column of water 34 feet.

Uses of the barometer. If something causes the air to become lighter, the mercury goes down. If

the air becomes heavier, the mercury rises or is pushed up. You have really made a simple barometer with which you may measure the pressure of the air. If there is a barometer in the building, study it and compare with your simple one. You will find that it is made on exactly the same principle. It has, however, a fixed scale that enables you to read the height of the column very accurately.

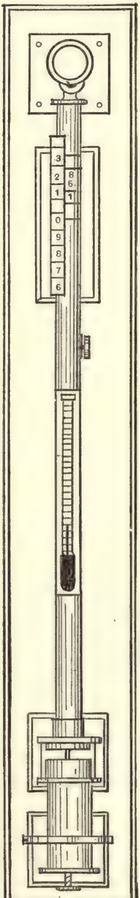


Fig. 72. A standard mercurial barometer.

You probably wonder why the air pressure varies from day to day. The chief cause of variation is due to different amounts of water vapor. Water vapor is lighter than the other gases of the air. When there is a large percentage of it present, the air is light. When there is little moisture, the air is heavy. A low barometer then indicates more moisture and the likelihood of storms; while a high barometer indicates a dry atmosphere and fair weather.

Since air pressure is due to the weight of the air, where will air on the earth exert the greatest pressure? You can think this out by placing all your books in a pile on your desk. Which one of the

books has the greatest pressure upon it? In precisely the same way the lowest part of the air has the most pressure, because of the weight of all the rest of the air above it. If you should take a barometer to the top of a high mountain, would the mercury go up or down? Why? If you lived one thousand feet above sea level, and you should take a barometer down to the sea, would the mercury go up or down? Why? Scientists know exactly how much the barometer falls with each foot of ascent at a given temperature, so a barometer may be used to determine how far above sea level any point is located.

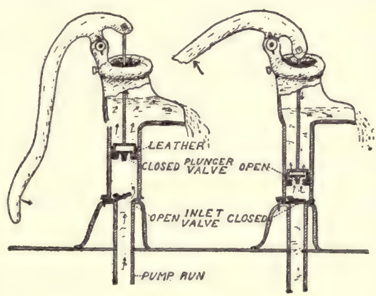


Fig. 73. A common suction pump showing piston, valves, etc.

Air pressure and pumps. Place one end of a glass tube open at both ends into a glass of water. Slowly suck the air from the tube. What happens? What forces the water into the tube? You no doubt see that as you remove the air from the tube the downward pressure on the water in the glass pushes the water upward in the tube. This illustrates in a very simple way what happens when you pump water with a common suction pump.

Study the parts of an ordinary pump. To what is the handle attached? What does the rod do as you work the handle? If possible, take the pump apart and find what is fastened to the rod at the lower end.

Making a pump. If you are skillful, you can make a miniature pump that will work exactly as the real one does.

Procure a straight lamp chimney, two pieces of cork, a glass tube, some pieces of thin leather and some wire. Make a hole in one piece of cork and fit the piece of glass tubing into this hole so that the tubing will come just to the surface of the cork. Over the hole place a thin piece of leather, fasten it at one end with a small tack or pin. This cork should fit closely into the lower end of the chimney. Make a similar hole in the second cork and fasten a piece of leather in the same way over the opening at the lower end. Fasten a piece of wire into the upper part of the cork. To this fasten a heavier wire. This cork should be trimmed off so that it will move easily up and down in the chimney, or it may be wrapped with thin muslin so that it will fit the chimney snugly.

You now have all the parts of a simple suction pump. The chimney is the pump barrel or cylinder. The cork that moves up and down is the piston and

the wire with which you move it is the piston rod. The tube at the lower end is the suction pipe. The pieces of leather covering the openings serve as valves that open or close.

Place the glass tube of the pump in a dish of water. Pull the piston upward. What happens? Now move the piston downward and watch. What effect did the lifting of the piston in the first place have upon the air in the cylinder?

A portion of the air was lifted up with the cylinder; hence the air pressure upon the water in the pan was greater than that in the cylinder and pushed the water upward through the lower valve. Watch carefully everything that happens when you move the piston downward. Why does the water move upward through the upper valve and why does the lower valve remain closed?

The pressure now is due to the force with which you are pushing the piston downward. This force of the water pushes upon the lower valve and holds it down, but the same force causes the water to push upward against the lower part of the piston, which opens the upper valve and gives the water a chance to rush through and fill the cylinder. This is exactly what happens when you pump water from a well. You can see the piston rod which is attached to the handle moving up and down in the cylinder. The

valves are at the lower part. The pipe extends down into the water of the well.

There are some other kinds of pumps but all of them are dependent upon air pressure to do their work.

The vacuum cleaner. The vacuum cleaner used in the home is a good illustration of air doing work. Study a vacuum cleaner. What are the main parts? How does it succeed in taking the dust out of rugs, etc.?

You find three chief parts to any vacuum cleaner whether it is large or small, whether it is run by hand or some other power.

1. A tube or barrel.
2. A piston that works in the tube.
3. A nozzle, with a small opening, by which the suction as it passes over the surface of objects is increased.

When you move the piston the air in the tube is pushed upward and escapes through a small hole in the upper part of the tube. The tube below the piston is almost emptied of air, so the heavier outside air rushes in carrying dust and other bits of dirt with it. The nozzle simply defines a definite space from which the air rushes in and from which all dust and dirt are soon cleared.

Other uses of air. Think of other ways in which

air is controlled by man so as to aid in doing work. Among these is the windmill which is constructed in a way to make air pump water. If you have a bicycle, you pump the tire full of air. Tires of automobiles are filled with compressed air. Compressed air is used in some places to run machinery.

Air and health. All life is dependent upon air. It is of the greatest importance to have plenty of pure air in our homes and schools. Pure air contains 20 per cent of oxygen, and does not have many dust particles floating around in it. The dust particles in air are of two kinds, dead dust and living dust. The former consists of bits of soil, ash, lint from clothing, and the like. This in itself is not really harmful unless there is a vast amount of it present. In that case it irritates the mucous membrane of the nose, throat and lungs, and thus weakens their resistance against disease germs.

Live dust consists of living organisms so small and light that they easily float about in the air by themselves, or more often upon the dead dust particles. They consist of spores of mold and other lower plant forms, and bacteria of various kinds, some harmless but others that produce human diseases.

Air in houses where people are living and working and where fires are burning is likely to become very impure unless care is taken to see that fresh air has a chance to come in.

What provision for ventilation is made in connection with the heating of your home or school room? Is the warm air that enters the room through the register pure? You can answer this question by going back to the furnace and tracing the cold air duct to its source. Does the air come from out-of-doors or from some room in the house? In many homes you find the cold air register in the hall. When this is the case great care should be taken to see that the air in the hall is kept as pure as possible. This can be done by keeping the hall window slightly open. When the cold air register is in the living or dining room, these rooms should be flushed with fresh air several times during the day by throwing open windows and doors.

Homes heated by hot water, steam or stoves are usually ventilated by means of doors and windows. A few buildings have special air shafts through which the impure air may be carried out of the rooms. In ventilating any room you must consider two things: 1. A place for the entrance of pure air. 2. A place for the exit of impure air. This means that there will be currents of air in the room. In fact, no room can be ventilated unless the air is in constant motion. If an opening is provided for the escape of impure air, plenty of fresh air will come in around doors and windows. An open grate or fireplace, though very

wasteful of heat, provides one of the best means of ventilating homes. The burned gases with air from the room pass up the chimney. Fresh, outside air pushes into the room through every crack and crevice. A stove, though not so good as a grate, serves somewhat the same purpose.

Experiment. What happens when you breathe?

You probably know that your breathing organs consist of the nostrils, trachea or windpipe, and lungs. Place your hands on the upper part of your chest with the tips of the second fingers touching each other. Now inhale, filling your lungs. Then exhale. Note what takes place in each case. Place your hands at your sides just above the waist line with the finger tips touching as before. Inhale and exhale, watching the movements. Watch the shoulders of some of your classmates, noting the breathing movements.

Respiration. These observations show that when you inhale the chest moves outward and upward, the ribs outward and the shoulders upward. The diaphragm, which is a muscular partition between the chest cavity and the abdominal cavity, moves downward. All these movements make the chest cavity larger, and, since the air that is in the lungs spreads out to fill the increased space, the air pressure in the lungs is less than that outside, so the air rushes in till

the lungs are filled with air of the same pressure as that outside. When you exhale, the ribs move inward, the chest and shoulders downward, so that the cavity

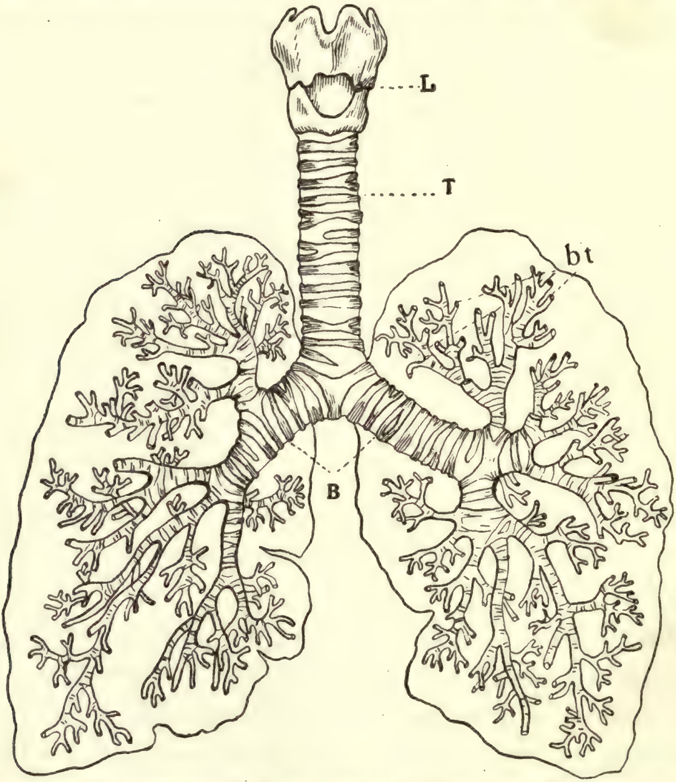


Fig. 74. L, Front view of the larynx; T, Trachea; B, Bronchial tubes; bt, Bronchioles.

is made smaller and the air is pressed or pushed out through the trachea and the nostrils.

In the lungs the air that is inhaled mixes with

the air that is already there and in this way a fresh supply of oxygen is brought in. The oxygen, however, to be of use must not remain in the lungs. It passes through the thin walls of little air sacs in the lungs, then through the walls of the small blood tubes into the blood.

If you could see the structure of a lung, you would find that the trachea divides into two branches called bronchi, one is a bronchus. These divide and subdivide into smaller and smaller tubes until finally each one ends in a tiny air sac made of thin membrane. It is from these little sacs that the oxygen passes into the blood. See Fig. 74.

The blood is composed of a thin watery fluid called plasma, and a great number of tiny floating bodies in this called corpuscles. Most of the corpuscles are reddish in color, a few larger ones are white. The white corpuscles are the purifiers of the body. They carry off and destroy disease germs and in other ways keep the body in good condition. The red corpuscles absorb oxygen from the air in the air sacs of the lungs and carry it to all parts of the body where it is needed. It is needed wherever there is work of any kind going on, or where heat is produced. To do its work, the oxygen leaves the red corpuscles of the blood and enters the cells of the tissues. Here it unites with the carbon that the cells have absorbed

from the food. The result of this union is that energy is produced and heat is generated. You see that heat is produced in precisely the same way as when carbon from wood or coal unites with oxygen in a stove or furnace, only in the body there is no accompanying flame or light, so we call the process oxidation instead of combustion. The union of the oxygen and carbon produces a compound called carbon dioxide, which is a waste product. This is taken into the lymph, then into the plasma of the blood and carried back to the lungs where it passes into the air sacs and is carried out with the breath.

Circulation. The relation of the blood and oxygen in the body is most interesting. All the blood from the lungs, with its load of oxygen, is collected into four large tubes or blood vessels called the pulmonary veins, which enter the left auricle of the heart. The heart has four compartments or chambers known as the right and left auricles and the right and left ventricles. The blood that enters the left auricle is what is ordinarily called pure blood; that is, it has a large amount of oxygen in the red corpuscles. From the left auricle the blood flows downward into the left ventricle. This ventricle contracts. That is, the walls grow thicker, come close together, and squeeze the blood out. It is prevented from going back into the auricle by valves between the two chambers which

are closed by the force of the blood flowing against them as the ventricle contracts. These valves act on the same principle as the valve in the ordinary pump. The blood is pushed into a large thick-walled artery called the aorta. From here it goes all over the body in tubes which branch out from the aorta. All these tubes are called arteries.

Put your fingers lightly on the sides of your throat. You can feel the pulsation of the two arteries which go to the head. At the wrist you can feel one of the branches that extends down the arm. The blood from the heart does not flow into the aorta in a steady stream, but in one impulse after another. The ventricle contracts and forces the blood out, then it relaxes and there is a pause. The blood would flow back into the heart at this time if there were not valves in the aorta to prevent it. This contraction and relaxation of the heart is the beat that you can feel. It also causes the pulse of the arteries, for the walls are elastic and expand and relax with the movement of the blood from the heart.

The arteries grow smaller and smaller toward the extremities of the body. Finally they break up into very small tubes called capillaries. These are so numerous that you can not pierce your finger or any other part of the body with the finest needle without breaking several of them. It is in the capillaries

that the oxygen passes out of the corpuscles into the cells. It is here, too, that the food which is carried in the blood flows out to feed the cells.

The capillaries unite and form small veins; these unite again and again, growing larger and larger until in the inner portion of the body there are very large veins. You can see the veins and their branches near the surface in your hands and arms. At last all the veins in the upper portion of the body unite into one large vein near the heart, and all in the lower part unite into another large vein. The upper one is called the descending vena cava, the lower one the ascending vena cava. These empty the blood into the right auricle of the heart. From here the blood goes into the right ventricle. The right ventricle contracts at the same time the left one does and sends the blood through the large pulmonary artery to the lungs. This blood, since it comes from all over the body, contains a large amount of waste products, especially carbon dioxide, which is given up to the air in the lungs and carried out with the breath.

Hygiene of breathing. From your observation of breathing movements it must be evident that if you fill all the air spaces in your lungs you must enlarge the chest cavity sufficiently to allow every portion of the lungs to expand. If clothing is worn too tight

about the waist, the movements of the ribs and diaphragm may be impeded and healthful breathing prevented. Out-door exercise causes rapid breathing and fills the lungs with pure air. If you do not take much out-door exercise it is a good plan to practice deep breathing at least twice each day. In the morning when you arise stand close to an open window or door and inhale as deeply as you can, then exhale promptly. Do this at least ten times. Do the same thing in the evening before you retire, when all your tight clothing has been removed. Another excellent habit to form is to breathe deeply as you walk along to school. Inhale while you take eight or ten steps. Then exhale either quickly or slowly. Repeat this ten or twelve times and you will feel the invigorating effects.

It is quite as important to have plenty of pure air during the night as during the day. This can be secured by keeping the windows in the sleeping room open all night, all the year around. Many people are building outside sleeping porches in order to sleep in pure air.

Diseases of the breathing organs. The diseases that commonly affect the breathing organs are colds, grippe, tuberculosis, and pneumonia. All of these are caused by disease germs or bacteria. Persons who have these diseases may scatter the germs by

ordinary breathing, but especially by coughing, sneezing and spitting. The germs fly around in the air and are inhaled by well persons. If a person is in excellent health, the white blood corpuscles may at once kill off the germs and he will feel no ill effects. On the other hand, the bacteria may get a foothold, begin to grow and multiply and bring on disease, at once or in a short time.

If all people who have these diseases were very careful not to scatter the germs, there would soon be none of them to spread. When you have a cold you should keep away from other people as much as possible. When you cough or sneeze you should hold a handkerchief over your mouth and nose. In no case should you spit upon the sidewalk or about the house. Tuberculosis is probably spread more by the habit of spitting than in any other way.

Clean air means clean homes, clean streets, clean alleys, clean clothing, and clean bodies. Since air is constantly moving, bits of dust with germs are constantly being carried around for people to inhale. Out-of-doors the air changes so constantly that there is little danger. But indoors the air may become so laden with germs that every breath carries some into the body.

To keep dust out of the home and school, then, is one of the ways to aid in preventing disease. Rugs

on the floors that may be taken out-of-doors frequently and cleaned, vacuum cleaners that prevent dust from being scattered, oiled cloths for dusting, all help to keep the air pure.

Moisture in the air. Another thing that we should give attention to is the amount of water vapor in the air, as the heated air of our homes is usually too dry for health. More moisture should be supplied. With steam or hot-water systems, vessels of water should be placed on or under the radiator so that moisture may constantly evaporate from them. What provision does a hot air furnace make for a constant supply of moisture in the air? Look at the side of the furnace for a small water pan. This opens into the jacket. Water in this pan evaporates and the vapor is carried with the warm air into the rooms.

CHAPTER XXIV

WEATHER

Materials. A thermometer, an almanac, daily weather maps, pages in your notebook to keep weather and sun records. Weather maps may be obtained by teachers for use in schools from the Weather Bureau at Washington or from the nearest weather station in the state.

Study. If you try to decide what the term weather means you will find that it includes many things that you have studied in the last three chapters. It means certain conditions of the atmosphere with reference to temperature, moisture and wind. Have you ever thought how closely the weather touches the lives of all people? Farmers, gardeners, and fruit growers are largely dependent upon the weather for success or failure in raising their crops. Weather conditions more than anything else caused primitive man to erect shelters from which have finally evolved our well-arranged, comfortable homes. Clothing, too, to a large extent, originated because man needed protection from the weather. Even now the weather has much to do with the kind of clothing

that is used during the different seasons. In fact, it will not be hard for you to make a long list of industries and customs that exist because of weather.

Man cannot control the weather, but by informing himself about the laws that govern winds and storms, and by keeping in touch with the information sent out by the Weather Bureau, he can usually plan his activities in a way to prevent the weather from injuring his crops or other work.

A good way to find out facts about the weather is to keep a weather record for a period of days or weeks. Place in your notebook or on a large piece of paper the following outline and keep the record for a month or longer. If you have no barometer leave out the column for pressure.

WEATHER RECORD

Date	Hour	Temperature	Wind Direction	Wind Velocity	Pressure	Sky	Precipitation or rainfall	Remarks
Dec.	9 a. m.	warm 60°	↑	Light	29.5 in.	cumulus clouds		Foggy this a. m.

Note to teacher: Weather observations and records should begin in the fall not later than November and be continued at least a week at a time until you are ready to take up the regular study after the chapters on heat, water and air. The record may be kept without interfering with the other studies.

These observations may be taken without instruments. However, if the school has a thermometer the temperature should be reported in degrees. If there is no thermometer then the terms warm, hot, very hot, chilly, cold, or very cold may be used.

The direction of the wind may be indicated by an arrow. An arrow pointing toward the top of the page indicates that the wind is traveling north. Is a wind named from the direction it is going or the direction from which it is coming? Velocity means the distance the wind travels per hour. The following words may be used to indicate velocity. These terms are suggested by the U. S. Weather Bureau. Calm, when there is no perceptible wind; light, when there is just enough wind to move the branches of the trees; brisk, when only branches sway; high, when whole trees sway.

Under sky, report whether it is clear, partly cloudy, or overcast, and the kind of clouds. Precipitation means falling weather of any sort—rain, snow, hail, etc. Under remarks, report any item of interest that does not appear under the other headings. Thus, for December 3, a heavy frost last night, or for December 16, a slight snow fell this afternoon.

At the end of the month make a short summary derived from your observations. How many fair days? How many cloudy? How many in which

there was precipitation? What was the general direction of the wind when the temperature was warmest? When the temperature was coldest? From what direction did the rain come? From what direction did the snow come? What was the direction of the wind during the cloudy weather, etc.?

Temperature. Your record will show some interesting facts concerning temperature, especially if your observation extends over a period of several months. Usually the temperature is lower in the morning than in the evening. It is highest early in the afternoon. One day may be very cold; the next from thirty to forty degrees warmer. Sudden changes in temperature are dependent upon wind direction and velocity, but the more constant changes throughout the day and from month to month are due to the relative positions of the earth and sun.

Arrange the following outline in your notebook. Make observations twice each week for a period of two or three months. The best time to begin is in the latter part of November or early in December.

Sun Observations

Date	Sunrise		Altitude of Sun at Noon	Sunset	
	Time	Position		Time	Position

To get the time of sunrise and sunset consult an almanac. This is more accurate than getting it by observation. Use great care in getting the position of the sun. In the first place try to find a spot from which you can see the sky down to the horizon. In the morning at sunrise or soon afterward stand facing due east. Is the sun north or south of that point? Now turn facing due south. How many degrees are there on the horizon between due east and due south?

Every circle no matter how large or how small has exactly 360 degrees in it. Since from the point due east to due south is one-fourth the distance around the circle of the horizon, it is, of course, 90 degrees between these two points.

Now face the sun and decide whether or not it is half way between east and south. If not, how many degrees south of east is it? Estimate as accurately as you can the number of degrees. Fix the position in relation to some object as a tree, telephone post, or building. Note carefully by means of this object whether or not the sun remains in the same position week after week. If it does not, determine which way it is moving.

Make the same kind of observations to determine the varying positions of the sun at sunset.

At noon stand out-of-doors where you can see the sun and sky. The point directly over your head is

called the zenith. Now face the south. Trace with your eye the curved line of the sky from your zenith to the point in the southern horizon directly in front of you. How many degrees is it?

Now determine the position of the sun on this line. How far above the horizon does it seem to be? Is it half way to the zenith? Fix its position with reference to some object and determine from week to week whether it is getting lower or higher. The distance the sun is above the horizon is called its altitude.

You can make a simple instrument with which to measure the exact altitude of the sun at noon. This instrument is called a clinometer. To make a clinometer use a square of cardboard or pasteboard. On this draw a quarter of a circle to represent the line from the zenith to the horizon. Mark this off into degrees from zero to ninety. Mark off the ninety into eighteen equal parts. Each part is five degrees. Now divide these into one-degree spaces. Tack the pasteboard onto a board and drive a nail a short distance into it at the square corner. Fasten the board a few feet from the ground on the east or west side of the house at the south end, so that the sun will shine upon it at noon. The shadow cast by the nail will fall upon the scale indicating the altitude of the sun. In making the clinometer you should know on which side of the house it is to be placed. If it is on the east side,

put the zero at the upper right-hand corner of the scale; if on the west, begin the scale at the upper left-hand corner.

Discussion. Your observations show that before December 22 the sun is moving farther southward both morning and evening. It also shows that its altitude is lower. After this date it moves northward and at noon its altitude is higher.

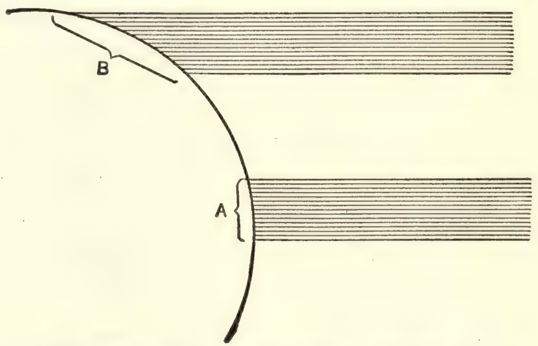
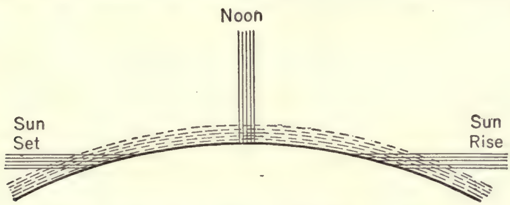


Fig. 75. The amount of heat received depends upon the angle at which the sun's rays strike the surface of the earth. The same number of rays fall on a smaller area at A than at B.

It is this movement of the sun that brings the seasonal weather changes. When the sun is far to the south its rays strike the earth with a greater slant than when it is farther north and higher at noon. This means that slant rays do not have as much power to heat the earth as those that are more nearly vertical.

A study of Fig. 75 will explain the reason for this.

The two sets of parallel lines represent the same number of heat rays from the sun striking the earth. With your ruler measure the difference in space covered by each set. Since A covers a much less space it can, of course, heat the portion that it strikes much more than if it were spread out to cover a space as large as B. Hence the slanting rays of winter cannot heat the earth as much as the more vertical rays of summer are able to do. The same is true during each day. The slanting rays of morning and evening do not have the same power to heat as the more vertical rays of noon.



g. 76. Diagram showing the difference in the angles at which the sun's rays strike the earth at sunrise, noon, and sunset.

You already know that the rays of heat from the sun called radiant heat are absorbed by the earth. The air near the earth is warmed, not directly from the sun but from the earth, partly because it touches the warm earth and partly because heat from the earth radiates into the air. When the heat rays of the sun strike certain objects on the earth the heat instead of being absorbed is reflected back into the air. From this you can easily see that the air near

the earth is much warmer than the air higher up. Some tests have been made that show the temperature from 12 to 15 degrees colder at a height of one mile above the earth and from 70 to 80 degrees colder five miles from the ground.

Clouds. If you have never formed the habit of observing the clouds you will find their study wonderfully interesting. The sky, like the sea, has endless variations which are due mostly to cloud formations. As you already know, clouds are masses of condensed water vapor floating in the air. Sometimes these masses are very low, not more than one-fourth of a mile above the earth. Sometimes they are six or seven miles high. They vary in appearance with their height, size, density and amount of rain in them. The names given to the most common cloud forms are cirrus, cumulus, stratus, and nimbus. Cirrus are light, feathery clouds that are high in the sky. Sometimes they are mere white streaks across the blue. These clouds rarely indicate an approaching storm. However, when they look like plumes with torn and frayed edges and are moving rapidly and gathering into larger masses, rain or snow is usually indicated.

Cumulus is the great mass of clouds so familiar in the summer time. Like great mountains with rounded tops, sometimes they are glistening white all over,

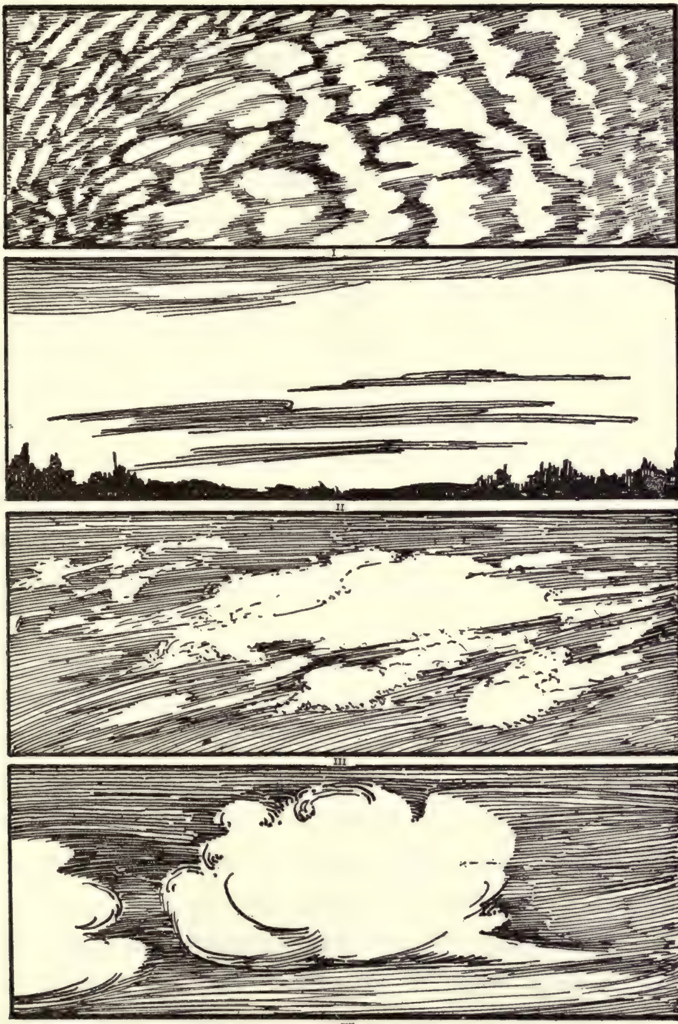


Fig. 77. Forms of clouds: I. Cirro-cumulus, often called a mackerel sky. II. Stratus, seen most frequently near the horizon before or after sunset. Cumulus clouds sometimes form in straight lines and are called cumulo-stratus. III. Cirrus; high, fringy clouds that seldom predict a storm. IV. Cumulus; when large often changing to nimbus, producing a sudden storm.

sometimes white on one side and dark on the other. Often they float around during the morning, then break up and disappear. When they do this they are called dry weather clouds. Sometimes they collect together growing larger and darker. When this is the case they usually bring a thunder shower. When they reach this stage they are called cumulo-nimbus.

Stratus are the clouds that appear as layers across the sky. Light ones are often visible at sunset and sunrise. They are also seen at other times during the day. Any cloud that has no special form but spreads out like a sheet or in layers is a stratus cloud.

Nimbus is a cloud from which precipitation is occurring; hence any of the other forms change to nimbus as soon as they begin to fall in the form of rain or snow.

Sometimes you will see rather high in the sky a wavy mass of white clouds which look like white curly wool. This is a combination of cirrus and cumulus known as cirro-cumulus. It is also spoken of as a mackerel sky. You will find other apparent combinations as strato-cumulus and cirro-stratus; high, white, feathery clouds in layers.

By watching the clouds every opportunity you have you will soon learn to recognize the different forms and be able to tell somewhat accurately what clouds are likely to bring rainfall.

Winds. Your study of convection currents tells you how wind is produced. It is nothing but a movement of air due to unequal pressure. The unequal pressure is caused chiefly by a difference in temperature. Heat makes the air expand and become light, The heavy air rushes toward the light area and the result is wind. All the winds on the earth's surface are caused in this way. You can see why there are constant winds blowing toward the heat equator from the north on one side and from the south on the other. The movement of the earth on its axis changes the course of these constant winds so that north of the equator they blow from the northeast instead of from due north, and south of the equator they blow from the southeast. These are known as trade winds.

Just as in a room the warm air from a radiator or stove is pushed upward, moves outward at the ceiling, becomes cooler and drops downward in parts of the room most remote from the stove, so on the earth at the equator the heated air moves upward, and when it reaches a certain height it spreads out, cools, and drops down to the earth again. We live in the part of America north of the region where the air drops downward. It spreads out toward both the north and south. We are in the northern belt. The deflection due to the turning of the earth upon its axis causes the air to move eastward, so we have what

are known as the westerly winds. They do not blow steadily eastward as you know. They are influenced by mountains and valleys and by local differences in temperature and pressure. We have constantly moving across the United States from west to east what are called "lows" and "highs." A low is an area of low air pressure, a high of heavy air, or high pressure.

In a low the air is moving from all sides toward the center. In a high it is moving from the center outward on all sides. The kind of weather we have depends largely upon whether a low or a high is passing over or near us. This movement is shown on a weather map.

Weather map. Study a weather map. Make a list of everything you find on it. Study the explanation given in fine print in the lower corner. This will enable you to interpret all the terms and symbols used. Trace a low as it moves eastward for several days and decide whether it brings fair or stormy weather. Trace several isotherms into a low to see in which part of the low the highest temperature is found. The isotherms are the dotted lines and connect places having equal temperature. In the same way trace the isobars. These are the solid lines. They connect places having equal pressure.

Weather maps are made under the direction of the Weather Bureau at Washington, D. C. The first weather observations for the public were begun in

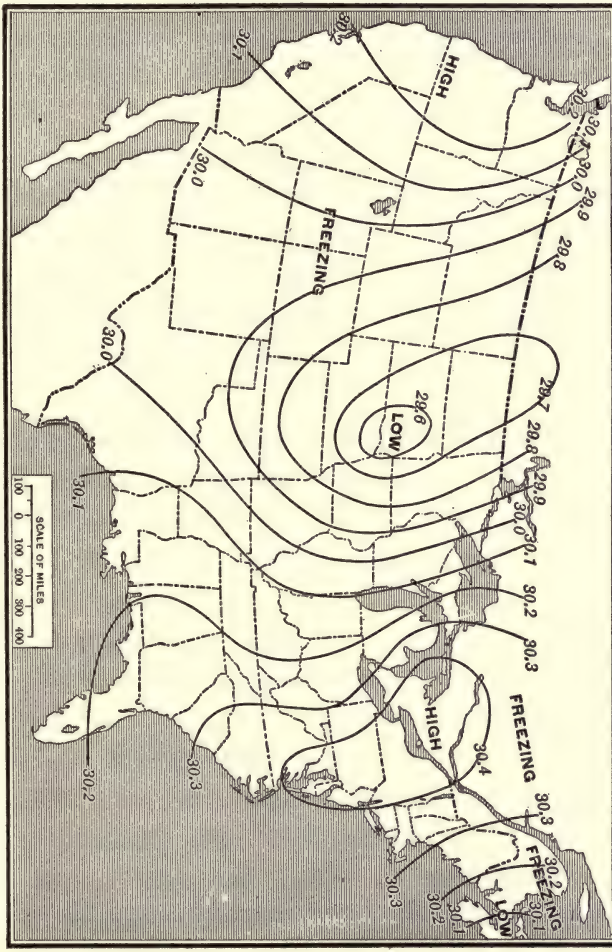


Fig. 78. A very simple weather map showing the air pressure in different parts of the United States on a certain day. Note line 29.9 showing the air pressure at two points in Canada, through Maine, Wisconsin, Iowa, Missouri, Oklahoma, Texas, etc. Find the "highs" and the "lows."

1871. The Weather Bureau became a definite part of the Department of Agriculture in 1891. The daily map gives definite facts concerning temperature, pressure, wind direction, velocity and rainfall all over the United States. When you learn to read one of these maps you can tell what kind of weather people are having in any part of the country. More than that, you can tell by the position of the lows and the direction they are moving what kind of weather you are likely to have during the next twenty-four hours. The weather forecast found on the map and printed in newspapers is made from a study of the weather map by men who are employed by the Weather Bureau.

Information for the making of maps is obtained from weather stations which are found in all parts of the country. At these stations observations are taken at 8 A. M. and again at 8 P. M. every day. These are telegraphed to the Weather Bureau and experts prepare the maps and send them out. Each state has a weather bureau center which prepares maps for its own region.

The value of warnings sent out by the Weather Bureau to agriculturists and seamen is beyond estimation. It is fair to state that property worth at least $30,000,000 is saved annually in the United States by the work of the Weather Bureau.

SPRING STUDIES

CHAPTER XXV

POULTRY AND POULTRY PROJECTS

Material. Poultry of the neighborhood, feathers and eggs.

Study. Make a list of all the different kinds of poultry in your community. Which kind is raised in greatest numbers? Do many people keep just one breed? How many keep several breeds? If you have poultry at home, find out the number of each kind, and estimate their present market value. Among your hens how many are more than one year old? How many pullets? How many cocks? How many eggs do you get daily? Try to discover by observation which are laying more, the pullets or the older hens.

Study of a chicken. Chickens, and all other poultry, are birds, and as members of that great group of animals they have certain characteristics.

Organs of locomotion. Note the feet. Are they placed near the front or the back part of the body? How many toes are there? Compare with one another as to length. How many are actually used in walking? What is found at the end of each toe? Do

hens walk on their toes or on the soles of their feet? What protective covering has the foot? Why are scales a better covering for the feet and toes than feathers? Look for chickens that have feathers on their feet. Try to find out how the toes hold the chicken on the perch. What other use is made of the feet than walking?

Watch a hen fly and note the movement of the wings. Spread out a wing and study the arrangement of the feathers. When the wing moves downward does the air pass between the large feathers? In what direction does the chicken move with the downward stroke of the wing?

At your first opportunity look at the bones of a chicken's wing and compare with those of your arm.

Watch the flight of wild birds. What use is made of the tail?

Procuring food. Watch a hen feeding. What is the chief organ that she uses? Describe the beak or bill and state what characteristics it has that fit it for its purpose. Is it hard or soft; sharp or blunt? To what extent does it differ in different breeds of chickens? Name the different kinds of food you have seen hens eating, and the different ways of using the beak. Is the food chewed or swallowed at once?

Sense organs. Name all the sense organs you can

find on the head of a chicken. Note the position, shape and color of the eyes. Can the hen see the same object with both eyes at the same time? Look for eyelids. If you have a tame hen that you can hold in your arm, touch the head near the eye and note what happens. Find the ears. Describe them. What evidence have you that hens and other birds hear well? Notice the position of the nostrils, the small openings on the upper part of the bill.

Feathers. Make a collection of all the different kinds of feathers that are found on one chicken. You should have one or more from the tail, the back, breast, neck, legs, and one from each of the different parts of the wing. These will include the stiff outer wing feathers, the primaries; the row of large feathers next to these, the secondaries; and the finer, overlaping feathers, the coverts.

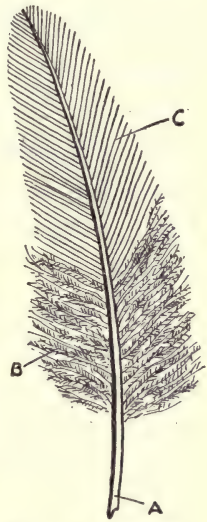


Fig. 79. Parts of a feather. A, Quill; B, Fluff; C, The web composed of barbs.

Examine one of the tail feathers. How many distinct parts do you find? What are the names of the parts? (See Fig. 79.) Pull the barbs of the web apart to determine how they are fastened together.

Compare the different feathers as to the amount of web and fluff. Which have more fluff, the feathers of the back or breast? Which of all the feathers have the least fluff? Which the greatest amount? What part of each feather is exposed to the weather? Look closely to see how much of each web is exposed. What is the value of this great overlapping? What is the use of the undercoat of fluff? Place the tips of your fingers close to the body in the fluffy part of the feathers. Now place them on the outer part of the web. Explain the difference in temperature. Recall what you learned about conductors and non-conductors of heat and decide in which class feathers belong.

How does the hen succeed in keeping her feathers smooth and in a condition to shed water? Watch one oiling and preening her feathers. Where is the oil gland situated?

Make a chart showing the different kinds of feathers.

Other types of poultry. If you have an opportunity make a comparative study of geese, ducks and turkeys. Note the special adaptations of the bills, feet and feathers of ducks and geese for life in or near water.

Discussion. Some of the questions that have arisen with your study cannot be answered by observa-

tion. The characteristics that you have discovered are in the main common to all birds and that gives them an added interest.

Perhaps you are not certain that the chicken walks on its toes. The segment that we often call the lower part of the leg is really the foot. The "drumstick" corresponds to your leg below the knee, and the second joint to your thigh. When a bird is on the roost the toes curve round the perch and the weight of the body bends the joints and tightens the sinews so that the bird sleeps without danger of falling. In fact, a perching bird has to rise up, straightening its legs somewhat, before it can release its toes from the perch.

The flight of birds is based upon a principle of physics. The large primary feathers, when the wing is spread, overlap to such a degree that no air passes between them. The bird strikes downward with the wing and the force exerted sends it forward and upward just as a boat is sent forward when you strike the water with the oar. The curved wing enables the bird to press harder upon the air than if it were straight. You noticed that the barbs on the front edge of a large wing feather lie close and almost parallel to the quill. This prevents them from being torn apart by the wind. With the up stroke the wing is turned slightly sidewise and offers less resistance

to the air. So while the down stroke pushes the bird upward and forward, the up stroke does not push the bird downward. The tail is spread in flight and serves as a rudder to guide the bird.

The bill of a chicken is well adapted to procuring food. It is sharp and strong and is used to break up hard particles as well as to pick up the food. As chickens have no teeth the food is swallowed whole. First it passes into the crop where it is moistened, then into the stomach where it is further moistened with digestive fluids, and then into the gizzard where it is ground up by small pebbles and other hard substances. The bill is also used as a weapon of defense, to preen and oil the feathers, and to turn the eggs during incubation.

The eyes of a chicken are closed by the lower lid instead of the upper. There is a thin semi-transparent membrane, sometimes called the third eyelid, present in the eyes of all birds. It spreads over the eye like a veil and is a protection against strong light and other injuries.

The ears are small irregular openings on the sides of the head. Usually they are pretty well covered with feathers. Although the external ear is so inconspicuous, birds possess a very keen sense of hearing.

Breeds of chickens. If there are representatives of

different breeds of chickens in your neighborhood, visit them, study their characteristics, and prepare to report in class. Collect from poultry journals and farm papers pictures of different breeds and make a chart or booklet.

Poultry raisers group the breeds into four great

Fig. 80. The dual-purpose-type.

classes: egg breeds, meat breeds, dual-purpose, and fancy breeds.

Egg breeds were originally European birds and are known as the Mediterranean class. They are small active chickens. The hens are noted for the great number of eggs they lay and for the fact that they rarely want to "sit." The most common va-

rieties are Leghorns, Minorca, Black Spanish and Blue Andalusian.

The meat breeds are known as the Asiatic class, because the original stock probably came from Asia. There are three common varieties, the Brahmas, Cochins and Langshans. They are very large, heavy chickens and produce a large amount of meat. They are not good layers and are of little value in raising chicks.

The general purpose breeds are more popular in most places than the others. They belong to the American class, because they have been produced by American breeders. They are medium in size and are comparatively good layers, hence they are useful in producing both meat and eggs. They are also better adapted than other breeds to raise and care for the young chicks. The common varieties are the Plymouth Rocks, Wyandottes, Rhode Island Reds, Orpingtons, and Dominiques.

Compare the different breeds with each other as to size, color, shape, and value. The fifth breed named above is of little practical value. Occasionally some one raises bantams or other fancy breeds for the novelty of it.

Care of poultry. In caring for your poultry you must consider: 1. Housing, 2. Feeding, 3. Arrangements for producing chicks.

Housing. What different kinds of poultry houses are there in your community? What points would you consider in making a poultry house?

Size and shape of the house. The size and shape are of some importance. The building should not be too wide. Sixteen feet is wide enough. Many are but twelve feet. The house should be large enough so that each bird may have a floor space of from five to six feet. A house twelve by twenty-four feet

Fig. 81. A good poultry house.

is about the right size for fifty hens, or perhaps sixteen by sixteen gives better floor space for arranging nests and roosts.

Connected with the poultry house there should be a run where the chickens may get out into the open air except in the most severe weather.

Light and air. It is very essential to have plenty of sunlight in the house. The way to manage this

is to have the building face the south with a number of windows. A house sixteen feet long should have two windows each containing eight square feet. Good ventilation is as important as plenty of sunlight. A way must be provided for exchange of air. Some poultry houses are so open that while there is plenty of fresh air, there are too many drafts. Many plans have been tried for securing ventilation without drafts. Probably the best method yet found is the cloth window pane. This may be made of muslin or cheese cloth and may be placed in one of the south windows instead of glass. It may be so arranged that during severe weather the glass window may partly close the opening.

Dryness. Too much moisture is detrimental to the health of poultry. This means that the building should be placed on well drained ground. Some poultrymen elevate the floor several inches with a layer of gravel. On top of this is a cement floor. Cement makes an excellent floor. It is easy to clean and at the same time keeps out rats.

Roosts. Roosts should be comfortable, and arranged so that cleaning may be easily done. There are many different devices. Perhaps the most satisfactory is to make the roosts out of two by two lumber with the upper edges rounded. Place them about two and one-half to three and one-half feet

from the floor. Under them place a platform to catch the droppings.

Nests. Proper placing of the nests is a problem of importance. Perhaps the most practical method is to place the nests under the platform described above. In this way the same floor space is used for nests and roosts. Many poultry raisers prefer to have platform, nests, and roosts movable, so that they may be taken out, cleansed and disinfected.

Describe the nests you have seen. What size were they? Were they placed in a strong light or in a dim light? There are a number of different kinds of nests. A nest should be from twelve to fourteen inches square and from six to eight inches deep. It should be shaded in some way from the strong light. Hens seem to prefer a rather dark place for their nests.

Feeding. Make a list of the different kinds of poultry foods used in your district. What grains are fed? Are they used dry or moist? Whole or ground? Chickens, like all other animals, need a certain amount of starchy foods, or carbohydrates, proteids, and fats. Laying hens require a large amount of proteid food because the white of egg is almost pure proteid. Every poultryman decides for himself the exact amount of the different feeds to give. Grain of some kind, part whole and part

ground, is used by all. The whole grains should be scattered in a layer of straw on the ground or floor so that the chickens will be compelled to exercise in order to get them. Meat scraps and sour milk supply the proteid. Green food of some sort is quite essential. This may be supplied by vegetables, such as cabbage, beets, turnips, etc., and by grass, clover, alfalfa and sprouted oats. Fine gravel or crushed oyster shells should always be supplied, as these aid the digestive process. Chickens require plenty of clean water as well as food. The drinking pan should be emptied and fresh water put in every day.

Chicks. How early in the spring do poultry raisers set hens? Start incubator? If possible, visit a a home where an incubator is used. Describe it. How is the heat supplied? Can you trace the convection current from its source to the eggs? How warm must the incubator be kept? The heat is usually supplied by a small oil lamp or gas heater. When the chicks are taken from the incubator how are they kept warm? Different methods are employed, but usually they are placed in a brooder, which is a small box with strips of cloth among which the chicks may cuddle down to keep warm. There are many different kinds of brooders, some of which are furnished with artificial heat.

The feeding of young chicks is of great importance.

For forty-eight hours after hatching the chick does not require any food. The yolk of the egg furnishes it food during this period. The first food may be hard boiled eggs chopped fine, shell and all, mixed with stale bread, cracked wheat or corn; or the first meal may be stale bread crumbs moistened in milk. After a few days the chick may be fed a mixture of bran, corn-meal, shorts, and scraps of meat. Most people prefer to use the food dry. Some poultrymen cook all the food for the first few weeks. With dry food plenty of milk should be used. Sour milk is quite as good or better than sweet.

Value of poultry. Name all the different products produced by poultry. How important are these products? What is the average price of eggs? Of spring chickens or broilers per pound? Of one-year old hens? What is the price of feathers? Poultry products are becoming more and more important each year. The demand for choice chickens and fresh eggs is constantly increasing and the prices are high enough to make poultry

Fig. 82. A good type of hen.

raising a successful business. When is the price of eggs highest? How may eggs be packed to ship by parcel post?

Poultry projects. You should begin to think about raising poultry on your own account if you live in the country or in a town where you may have space enough for a small house and run. Choose a breed that you think will give best returns. You can start with one hen and a setting of eggs, or you can buy a number of young chicks that are a day or two old. If your parents raise poultry you may get enough from them for your start. Many poultrymen sell and ship large numbers of young chicks. Keep a very careful record of your project.

Record.

1. Expenditures.
   a. Number and market value of chickens you start with.
   b. Cost of necessary equipment.
   c. Cost of feed.
   d. Approximate cost of labor.
2. Receipts.
   a. Number of eggs.
   b. Value at market price.
   c. Number of chicks raised.
   d. Value of those sold.
   e. Value of those kept for breeding purposes.
   f. Value of those used at home.
3. Net profits.
4. Notes that will be of value for future reference.

If you live in a place where ducks or geese are

raised, you may be interested in starting a project with these instead of with chickens.

A poultry club in the school will add to the value of the projects. If this is undertaken, plans should be made for an exhibit with a display of eggs and chickens or other poultry. If practicable a poultry house may be equipped on the school grounds and poultry raised on a cooperative plan. Some of the children may take the responsibility of caring for the stock during vacation.

CHAPTER XXVI

BIRDS

Material. Birds of the community, charts, pictures, books and notebooks; when possible a pair of field or opera glasses.

Study. You should become acquainted with every bird in the vicinity of your home and school. There is but one way to accomplish this and that is to study birds at first hand, out-of-doors. Getting acquainted means not only learning to identify birds, but finding out everything you can about their lives and habits.

If you are not familiar with many birds, you cannot begin your observation at a better time than late winter or very early spring. At this time the number of different birds is not great and you can easily learn to know them all before the spring migration brings in a large number of new species.

In order to make an intelligent study, you should know the names of the different parts of a bird. Study Fig. 83 until you are able to name all the parts when you look at a live bird. When you go out on a field trip, form the habit of taking a small notebook with

you. Reserve two pages for each bird. The following outline will be found helpful in keeping a record:

1. Date:
2. Weather conditions:
3. Name:
4. Where is the bird:
5. Size: compare with wren, English sparrow, robin, crow.
6. Colors:

    Head......... Crown......... Nape......... Bill.........
    Back......... rump.......... wings......... tail.........
    Throat...... breast...... belly...... sides...... feet......

7. Movements and habits. Note special characteristics of flight, movements upon the ground, feeding habits and food, nesting habits, time of nesting, material used, location of nest, share of the work done by the male, by the female, care of the young.

Do not think that you must make a complete record with your first observation, but add to it from time to time as you become better acquainted with the bird. One of the interesting things about bird study is that no matter how long you may have known a bird, you are constantly finding out new facts about it.

Suggestions for field study. 1. Move slowly and quietly. 2. If you have companions avoid talking to them, or speak in a very low tone. 3. Study one bird till you are sure of its colors; do not try to study two or three at the same time. 4. Listen attentively to the notes and songs so that in time you will be able to identify birds by sound, as well as by sight.

5. Learn to imitate as many of the notes as you can. 6. As far as possible keep the sun at your back in order to see the colors more distinctly. 7. Plan to make some studies in the early morning. An hour before breakfast will often give better results than two or three hours in the middle of the day. Next to the early morning hours the late afternoon is the best time to see birds.

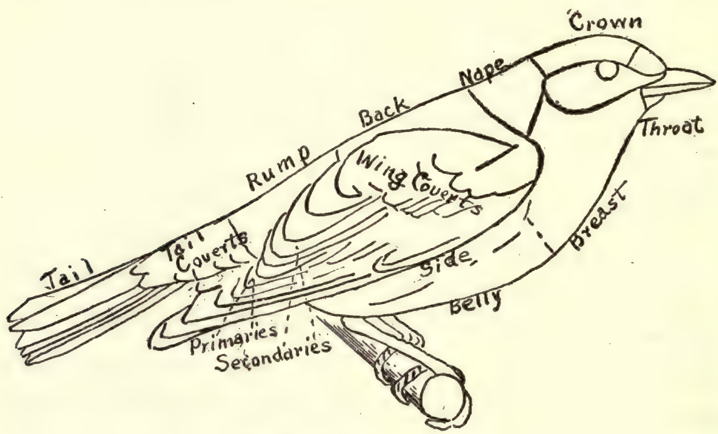


Fig. 83. Parts of a bird.

Bird Groups. Birds may be grouped into four classes with reference to the period of time and the season during which they remain in your locality.

1. Permanent residents are the species that are found in the same region the year around.

2. Winter residents spend the winter in one local-

ity and go farther north to nest and rear their young.

3. Summer residents nest in one region but go farther south to spend the winter.

4. Migratory visitors are birds that nest in the far North, winter in the South, and stop at places between for a few days or weeks during their spring and fall journeys. You may discover for yourself the many birds that belong to each of these different groups.

Birds may also be grouped with reference to their structure and appearance. Orinthologists have used structural characteristics to classify birds into orders, families, genera and species.

If you look in any good bird book you find besides the common name, a scientific name. This is made up of two words designating the genus and the species. If, for example, you look at the description of a flicker, you find in italics after the common name *colaptes auratus,* which is the scientific name. Then if you look farther you find that the flicker and all other woodpeckers are placed in a group by themselves because they all have similar characteristics. These constitiute the woodpecker family. A number of families that have similar characteristics are put together into a larger group called an order.

It is worth while finding out some of the family

characteristics of the birds with which you become acquainted. The parts of a bird that are commonly considered in placing birds into family groups are the bill and feet. The nesting and feeding habits and the musical powers are in many cases also considered.

Descriptions. Select a number of good bird pic-

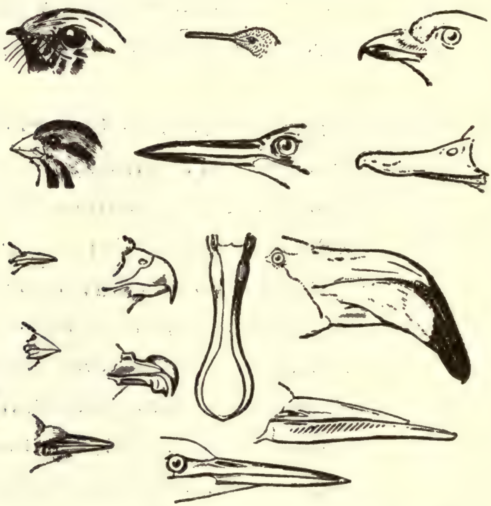


Fig. 84. Adaptations in the bills of birds.

tures. Compare the bills and feet to determine how they differ. Put together those that have similar bills and you will probably have some representative family group.

Families. Describe the bills of song sparrows,

the vesper sparrow, the goldfinch, the cardinal, the rose-breasted grosbeak.

You find in every case a stout, rather short, conical bill. These birds belong to the sparrow or finch family. The hard stout bills are adapted for

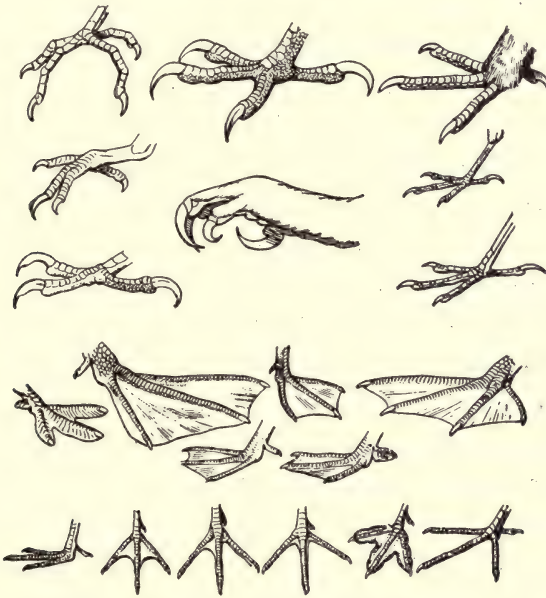


Fig. 85. Adaptations in the feet of birds.

the crushing of seeds. These are the great seed eaters among the birds. Many of them are also noted for destroying insects, especially hard-shelled insects. The rose-breasted grosbeak is one of the few birds that is especially fond of the potato beetle.

The bills of the members of the swallow family are short and sharp and very wide at the base. These birds spend most of their time on the wing catching insects in the air. Their wide mouths are admirably adapted to this kind of life. They have very long wings and rather small, weak feet. When they alight they choose a telephone wire or a small twig which their small toes can grasp with ease.

If you look closely at pictures of wood warblers you find the bills long, slender, and pointed; just the kind to snap up insects from the leaves or bark of trees and shrubs. The warblers are all small birds and most of them are brightly colored.

The mockingbird family has long, rather slender, slightly curved bills. Their bodies are slender and their tails long. They are noted for their wonderful musical power. Besides the true mockingbird, the brown thrasher and catbird are the most common members of this family.

Wrens are closely related to the mockingbirds, but are placed in a family by themselves. Their bills are similar to those of the mockingbirds. They, too, are great musicians.

The creeper family is represented by but one species here in America. That is the small brown bird that you see creeping up the trunks of trees. The bill is very slender, curved, and sharp pointed. With this

needlelike bill the bird is able to get insect eggs and tiny larvae from the smallest cracks and crevices of the bark.

The thrush family includes two of our most familiar birds, the robin and bluebird. The bills are long, rather slender, and pointed. They are adapted for eating either insects or fruit. All the thrushes except the two common birds named have spotted breasts. You may have observed that the young of both robins and bluebirds have the characteristic spotted thrush breast. The thrushes rank high among bird musicians.

If you have examined the bills of the kingbird, pee wee, or phoebe, you note that they are slightly curved at the tip and wide at the base. These birds belong to the fly catcher family. This family is noted for catching insects on the wing. The bird usually sits on a dead branch of a tree watching for insects. As one flies by the bird darts out and skillfully catches it, usually returning to the same perch again and again.

The blackbird family comprises a large number of birds that differ considerably in their habits and structure. Their bills are rather long, deep, and pointed, adapted to picking up a variety of foods, insects, seeds, and fruits. Some of them have very little musical ability, while others are good songsters. Besides all the different kinds of blackbirds, the

meadow larks, orioles, and bobolinks belong to this family.

All the families we have described thus far belong to one great order called passeres or perching birds. The arrangement of the toes is the same in all of these birds; that is, three toes point forward and one backward.

The members of the woodpecker family have strong, slightly blunt, chisel-like bills which enable the birds to peck holes in trees. The foot has two toes that point forward and two that point backward. This arrangement, with the sharp claws, adapts the foot to tree climbing. The tail also aids in climbing. You notice that it is short and that the feathers are pointed and stiff. They help to prop the bird against the tree while it is creeping upward. The tongue of the woodpecker is quite remarkable. It is very long and ends in a hard tip with sharp barbs along the side. This enables the bird to draw from their hiding places the borers that feed under the bark of trees.

Hawks, eagles, and owls belong to an order known as raptores or birds of prey. All of these birds have strong hooked bills adapted for tearing flesh, very strong feet and claws used for catching and carrying prey, and long strong wings that enable them to fly great distances.

Shore birds. If you live near water, lakes, ponds,

or rivers you will have an opportunity to become acquainted with shore birds and swimmers.

The shore birds are represented by the snipes, sandpipers and stilts. They have very long slender bills which enable them to probe around in mud and sand in search of insects and other choice morsels to eat. The legs are long and are bare above the heel joint. This makes it possible for them to wade in shallow water without getting the feathers wet. The neck also is long.

Ducks and geese are common representatives of the family of swimmers. The bill is flat and broad with a sieve along the edges of the mandibles. When the birds get their mouths full of water, thin mud, and particles of food, the sieve allows the water and mud to flow out and leaves the food. The toes of these birds are webbed so that they may be used as paddles in swimming. The body is boat shaped, a characteristic which also aids in swimming. Besides ducks and geese, swans belong to this family.

Value of birds. Make a list of all the ways in which birds are of value to us. It is no easy matter to estimate accurately the good that birds do in the world. They destroy countless numbers of insect pests. It is probably fair to say that without the aid of birds many of our farm crops would be partially if not wholly destroyed every season. It is not

farm crops alone that birds protect, but also gardens, orchards, and forests.

You have only to watch a pair of wrens, thrashers, robins or grosbeaks during the nesting season, working incessantly from dawn to dark collecting insects from the yard and garden, to appreciate what great benefactors they are. The seed-eating birds, the finches and sparrows, aid us in devouring quantities of weed seeds every year. The birds of prey, hawks, and owls, are of great importance because of the number of small rodents, mice, rats, gophers, ground squirrels and the like, that they destroy.

Aside from their economic value birds are of importance because of their influence upon our lives. No other phase of nature can bring more genuine pleasure than bird study. To know birds, to appreciate their beauty of song and color, to love them for themselves and for their interesting ways and habits, will bring you joy not only now, but all the days of your life.

Enemies of birds. Make a list of the enemies of birds.

1. Destruction of nesting places. The clearing of woodlands is progressing to such an extent that in many localities the birds are disappearing because they no longer have places in which to build their nests and rear their young. The breaking up of prairie lands and the draining of swamps in the

Middle West have already driven large numbers of birds from that region.

2. Destruction of drinking and bathing places by the draining of ponds, open ditches and small streams.

3. Cats. Professor Forbush, of Massachusetts, estimates that a single cat is responsible for the death of about fifty song birds a year.

4. The robbing of nests by boys who have a mania for collecting eggs.

5. The destruction of birds for millinery purposes.

6. English sparrows. These foreign birds drive away from our homes many of our most beneficial and beautiful song birds.

7. Red squirrels. These are becoming so numerous in some towns that they are destroying scores of bird nests every season.

Protection and care. You can do much, not only to protect birds from their enemies, but to actually increase the numbers in your community. One of the first things is to provide nesting places. Every country community should have a bird refuge in connection with each farm. A few shrubs or low trees along the highway or in clumps in fence corners will keep in the neighborhood scores of useful birds that will pay for their nesting site by destroying myriads of noxious insects.

Boxes or bird houses may be provided for birds that

nest in cavities. Use old weather beaten lumber, or, if new material is used, paint the houses a dull gray or brown. For wrens and chickadees make the hole for the entrance about one inch in diameter. This will prevent English sparrows from entering. Larger birds that nest in boxes are the bluebird, tree swallow, purple martin, nuthatch, flicker, titmouse, phoebe, and screech owl.

Tin cans, old tea and coffee pots, and gourds may be used instead of boxes. You can attract some birds by furnishing building material for them. Place twine or yarn on bushes for orioles, a pan of mud for robins, and hairs, dry grass, rootlets and threads for other birds. Birds need water both for drinking and bathing. Pretty bird basins or baths may be purchased, but you can easily arrange your own at small cost.

A little basin of cement with sloping bottom and fringed with rocks and ferns may be placed in a hollow in the back yard. Common granite iron pans from two to four inches deep may be used. Place a layer of clean sand or fine gravel in the bottom or a flat stone for small birds to stand upon. If the pan is set upon a block or stump a few feet from the ground, cats are not so likely to disturb the birds while in the bath.

Help get rid of all the stray cats in the neighbor-

hood. If you have cats of your own, feed them with a meat diet so they will not attack the birds because of hunger. Do all you can to train them to leave birds alone, or keep them indoors during the nesting season.

Birds may be kept near your home all winter by supplying food for them. Nuthatches, chickadees, hairy and downy woodpeckers, brown creepers as well as jays, will feed upon beef suet tied firmly in the crotch of a tree or suspended from a branch. Meat rinds or shank bones may also be used. Native sparrows, juncoes, gold finches and other seed eating birds may be attracted by a feeding tray made out of boards and fastened to some support four or five feet high. This tray should be kept supplied with chaff from the haymow, sunflower seeds, millet, and other seeds. During the early spring days when insect food is scarce, robins and bluebirds enjoy crumbs from the table.

Consult the Shrub List, page 460, to find what shrubs have berries that attract birds both in summer and winter. Besides the shrubs, the following trees furnish attractive food for birds: white and red mulberry, mountain ash, hawthornes, June berry, wild cherry and flowering dogwood.

Do not wear birds on your hat, even if the milliner insists that they are made of chicken feathers. The

principle remains the same whether they are real or artificial.

With the help of your teacher, look up the laws of your own state for the protection of birds and do all you can to see that they are enforced.

Bird Lists

1. Birds that feed upon insects injurious to field crops: Meadow lark, bobwhite, dickcissel, indigo bunting, killdeer, Maryland yellow throat, redwing blackbird, bobolink, brown thrasher, bronze grackle, cowbird, horned lark, song sparrow, field sparrow, other native sparrows, plover.

2. Birds that feed upon insects injurious to garden and fruit crops: House wren, catbird, rose-breasted grosbeak, robin, bluebird, oriole, chickadee, downy and hairy woodpecker, chipping sparrow, yellow warbler, nuthatch, brown creeper, mocking-bird.

3. Birds that destroy flying insects about the home: Chimney swift, barn swallow, tree swallow, purple martin, kingbird, night hawk, phoebe.

4. Birds that are especially beneficial to forest and shade trees: All the warblers, scarlet tanager, summer tanager, the cuckoo, vireo, thrush, pewee, titmouse, whip-poor-will, chuck-will's-widow, chewink, white-eyed vireo, all woodpeckers, nuthatch.

5. Birds that feed upon weed seeds: Goldfinch, white-throated sparrow, white-crowned sparrow, tree sparrow, junco, mourning dove.

6. Birds that destroy mice, ground squirrels and injurious rodents: Red-tailed hawk, red-shouldered hawk, marsh hawk, rough-legged hawk, screech owl, short-eared owl, barred owl, snowy owl, barn owl, horned owl.

CHAPTER XXVII

LANDSCAPE GARDENING

If you look at any well arranged home or school grounds you find five distinct kinds of plants used to make them attractive. First there is grass in the lawn or open stretches, then there are trees, shrubs, vines and flowering plants. The artistic arrangement of these different groups of plants in relation to each other and to buildings, walls, and walks or drives constitutes what we call landscape gardening. The men and women who make a business of planning and planting such grounds are known as landscape gardeners or landscape architects.

While you can not attempt to do the work of the landscape gardener, you can learn some of the underlying principles, and, in cooperation with your parents and teachers, undertake a few projects to make your home and school grounds more beautiful. This need not interfere with your vegetable projects. You may very well undertake the care of a vegetable plot and a home improvement plan at the same time.

The Lawn

In any plan for improvement of grounds the lawn should receive first consideration. It is the canvas of the landscape picture "upon which the artist paints with tree and bush and flower as the painter does upon his canvas with brush and pigment."

In all the states north of latitude 38 to 40°, Kentucky blue-grass is the favorite lawn grass. For special conditions, such as very shady spots, dry sunny slopes, or for low wet lands, other grasses are mixed with this. In fact, other seeds are frequently mixed with blue-grass in starting an ordinary lawn. Some people use other grasses and some use white clover. Barron in his book entitled "Lawns" suggests the following mixture for any lawn that has a clay soil:

Kentucky blue-grass	50%
English rye	20%
Fancy red top	30%

The rye grows rapidly and covers the surface with green in a short time. After a few years if the blue-grass does well, it takes complete possession of the space. In the South, Bermuda is the chief lawn grass.

Other mixtures suggested by the same writer are:

For terraces or slopes	
Creeping bent or Rhode Island bent	40%
Crested dog's tail	25%
Canada blue-grass	25%
Kentucky blue-grass	10%
For shaded places	
Kentucky blue-grass	40%
Wood meadow grass	40%
Various leaved fescue	10%
Crested dog's tail	10%

Some localities are so shady that it is impossible to get a stand of grass. In that case other plants may be used to cover the ground and give a pleasing effect. Myrtle is excellent for this purpose. So is common ground ivy.

Blue-grass. Material. A grass plot in home or school yard; a small piece of sod taken from some corner where it will not be missed; specimens of seed heads; seeds.

The suggested topics for blue-grass may be used for any other lawn grass.

Problem. What are the characteristics that make blue-grass a good lawn grass? Note the habit of growth of the grass. Try to separate the individual plants from each other. How close together are they? Try to pull up one grass plant. What happens? Why does it break off instead of coming up by the roots? What direction do the leaves take in their

growth? How are they fastened to the stem? Remove a leaf and examine it. Compare the lengths of sheath and blade. Determine whether the blade is flat or folded toward the mid-rib. Examine a number before you decide.

Rootstock and roots. Examine the piece of sod. How many distinct structures do you find penetrating the ground? Describe each. Wash all the soil out of a small piece in order to see the parts clearly. What is the greatest number of rootstocks that you find growing from a single plant? What is the direction of growth? What is there at the free end? Of what advantage to the plant is the rootstock?

Seeds. Study the seed-head. How tall is it? How does it branch? Where are the seeds? Remove all the seeds from one head and measure. Describe the seeds as to size and color. Compare with those of other grasses. Make a collection of all the different heads of grass seeds available and mount them on a stiff cardboard.

Experiment. Effect of depth of planting on germination and growth. In a box of soil plant several rows of seeds at depths varying from a mere covering to two inches. Determine which germinate and grow best. If possible make the experiment out-of-doors also. What is the price of blue-grass seed? How large a space will a pound sow? How many

pounds in one bushel? How much will it cost to sow an acre?

The home lawn. Examine your home lawn. Which way does it slope? Has it any terraces? Is it in good condition? If not, what can you do to improve it? Look for dead leaves and other trash, bare spots, weed patches, uneven spots. What rules are followed regarding mowing?

Discussion. From your observation you find that blue-grass grows in a very crowded condition. This is one of the characteristics that makes it an excellent lawn grass.

The underground parts are quite as important. You found the great mass of fine fibrous roots that help to make a firm turf or sod and the thicker rootstock which is an underground stem. If you examined it closely you found that it has nodes with scale leaves, and a growing bud at the end. The rootstock grows horizontally and enables the grass to spread evenly over the ground. It is a great advantage to the plants during severely cold or dry weather. All the parts above ground may be killed, but the rootstock with its buds remains uninjured and sends up new plants as soon as the proper conditions of moisture and warmth are restored.

Blue-grass sends up its flowering head in the early summer, and the seeds ripen within a few weeks.

This kind of a head with many branches is called a panicle.

Starting a lawn. If you wish to start a new lawn, the first requirement is a deep seed-bed of rich mellow soil. Level the surface, leaving a slight slope from the house to the road or street if desired. You may start a lawn in two ways, by the use of sods or by seeds. The latter is less expensive and is the one commonly used. The seed may be sown in the fall any time before the ground freezes, or in the spring. Spring seeding should be done as early as possible so that the plants will get a fair start before dry, hot weather.

Choose a day to sow when the wind is not blowing briskly, scatter the seeds evenly and thickly, about one pound to 100 square yards. Rake the soil lightly. If possible run a roller over it. If it does well it will be ready to mow in six weeks or two months.

Caring for the lawn. If you find bare spots in your lawn rake out all the trash, put in some fresh soil, then seed thickly. If there are weeds dig them out and sow grass seeds in their place. If the lawn is uneven the use of a heavy roller will greatly improve it. Rolling at least once in the spring is good for any lawn whether uneven or not.

The lawn should be mowed often enough to keep a smooth velvety grass covering. In dry weather care

should be taken not to mow too close to the ground as there is danger of injuring the roots. In fact, it is best to have the mower set high at all times. Evening is a better time for mowing than morning. Do you see why? The grass has the cool night in which to recover from the shock of the cutting. In dry weather it is best to allow the clippings to lie instead of catching them or raking them up.

If you water your lawn you will find that a thorough drenching once or twice a week will keep it in better condition than a light sprinkle every day.

Home projects. No home project that you can undertake will give you more real pleasure and satisfaction than caring for the lawn. You will have some enemies to contend with. The most common and the hardest to combat are weeds. Removing them root and all is the surest way to get rid of them. Do not allow a single one to go to seed. (See Weeds, p. 77.)

1. Shrubs

Material. Shrubs of the neighborhood, park, nurseries, and woodlands, catalog containing price lists.

Study. Make a list of all the shrubs in your district whose names you know. Choose several for special

study. What is their habit of growth? How do they differ from trees? What is the height and color of the stem? Are the twigs stiff and erect or drooping? Examine the twigs for buds and scars. Which shrubs have retained their fruit or berries over winter? Have you seen any birds feeding upon them? Keep a simple shrub calendar showing dates of the opening of leaf and flower buds. How are shrubs usually propagated? (See Cuttings, p. 263.)

Make a list of native shrubs in nearby woods. How many of these do you find on home or school grounds?

Notice the homes in your district and decide which ones have the shrubs arranged most artistically. How many of the rules for shrub planting do you know?

Discussion. Shrubs, more than any other plants, may be used to give a beautiful, natural setting to a home. They differ from trees in that they send up a number of stems from the root instead of one main trunk. They never grow as tall as trees and many of the most beautiful ones have drooping branches. In cool climates they have the same habit as trees in preparing for the winter season; that is, they start their buds in the latter part of the summer, cease their work, and the deciduous ones drop their leaves.

Projects. If you are planning to set out shrubs

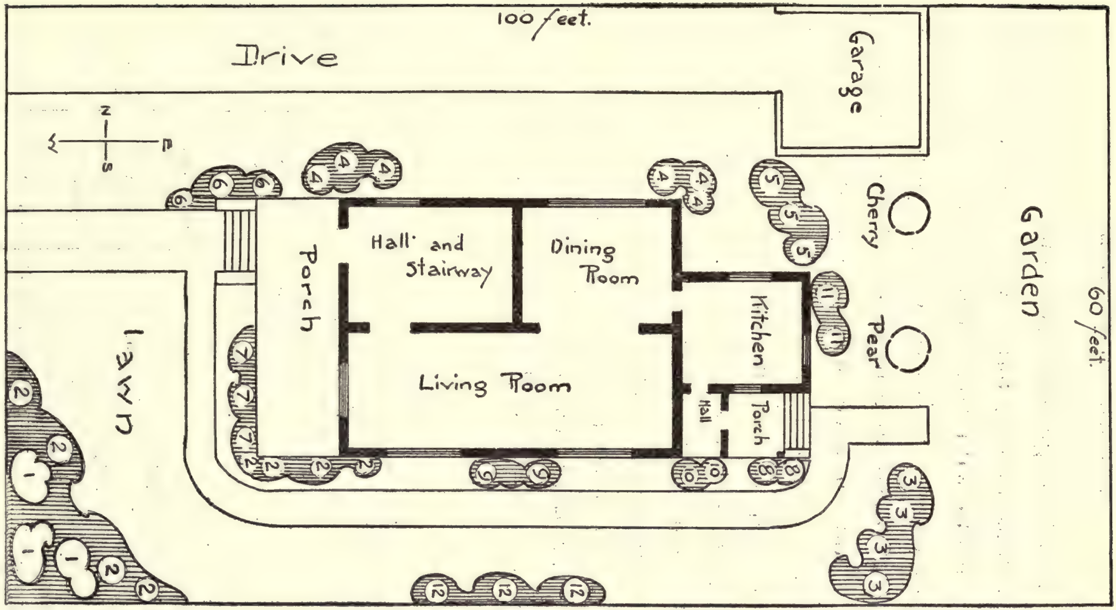


Fig. 86. Planting plan for small grounds: 1 Spirea Van Houttei, 2. Japanese barberry; 3 Hydrangea paniculta; 4. Indian Currant; 5. Bush honeysuckle, Lonicera Morrowii; 6. Deutzia gracilis; 7 Clematis paniculta; 8. Virginia creeper, 9. Hardy phlox or pinks, 10. Hardy chrysanthemum or gaillardia; 11. Tulips or Hyacinths followed by geraniums or gladiolus; 12. High bush cranberry. (Cost from ten to twenty dollars, depending upon the size of the plants.)

on home or school grounds you must know not only the best shrubs to use, but how and where to place them. To begin with you should observe the following general rules: 1. Leave an open lawn with the shrubbery grouped at the sides or near the buildings. 2. Plant to give mass effect; do not scatter the shrubs. 3. Avoid straight lines except in the making of hedges. 4. Put together colors that will harmonize, or plan for a succession of flowers.

With the consent of your parents draw up a plan for the planting of your home grounds. The work need not be completed in one year. Start it now and continue year after year till it is finished. It is very important to have a well arranged plan before you begin.

SHRUB TABLE

The date of flowering is given for regions in about 40° north latitude. N. after a name indicates that the shrub is native to this country. Shrubs that are starred are especially attractive to birds.

Name	Date of flowering	Color of flower	Color of fruit
Low—from 2 to 4 ft.			
*Japanese barberry.......... Berberis Thunbergii	June	Pale yellow	Scarlet
Indian currant N.......... Symphoricarpus vulgaris	June	White	Red
Sweet scented sumac N.... Rhus aromatica	July	Yellow	Dark red
Dwarf spirea Spirea Japonica	March-April	White	

Name	Date of flowering	Color of flower	Color of fruit
Early spirea.............. Spirea arguta	March-April	White	
Low hydrangea N......... Hydrangea arborescens	July	White	
New Jersey tea N.......... Ceanothus Americanus	June	White	Black
Spice bush N.............. Calycanthus floridus	May	Dark purple	
Low deutzia............... Deutzia gracilis	June	White	
*Honeysuckle .... Diervilla lonicera	May	White	Red
*Dwarf sumac N........... Rhus copalina	July-August	Greenish	Red
Medium—from 5 to 7 ft.			
*High bush cranberry N.... Viburnum opulus	May-June	White	Bright red
*Arrowwood N............. Viburnum acerfolium	June	White	Red
Golden bell Forsythia intermedia	March-April	Yellow	
*Honeysuckle .... Lonicera Morrowii	May-June	White-yellow	Red
Spirea .... Spirea Van Houttei	May	White	
Snow berry N............ Symphoricarpus racemosus.	June-July	Pink	White
White kerria.............. Rhodotypos kerriodes	May	White	Black
Weigelia .... Weigelia rosea	May-June	Rose	
*Flowering currant N...... Ribes aureum	April-May	Yellow	Black
Dogwood N............... Cornus stolonifera	May-June	White	Whitish

Name	Date of flowering	Color of flower	Color of fruit
Hydrangea .... Paniculata grandiflora	July-August	White-rose	Bronze
False Indigo N............ Amorpho fruticosa	May-June	Blue	
Privet .... Ligustum amurense	June	White	Black
Privet .... Ligustum regels	June	White	Blue
High—from 7 to 12 ft			
*Elder N.................. Sambucus canadensis	July-August	White	Black
*Honeysuckle .... Lonicera tartaria	May-June	Pink	Red
*Sumac N................. Rhus typhina	June-July	Red	Red
Button bush N............ Cephalanthus occidentalis	May	White	
Japan quince.............. Pyrus japonica	April-May	Red	
Mock orange, Syringa....... Philadelphus coronarius	June	White	
Lilac .... Syringa vulgaris	April-May	Lavender	
Sweetbrier rose N.......... Rosa rubiginosa	June	Pink	Red
Prairie rose N............ Rosa setigera	June	Pink	

You have such a large number of shrubs from which to choose that you may find it difficult to decide which ones to use. As far as possible, select those that are native to your locality. While you may get some of them directly from the woods, they usually give better

results if obtained from a nursery where they have been grown under conditions similar to those of your home grounds. From your study of cuttings you know that if you are willing to wait a year or two for results, you may start many of you own shrubs.

Border planting. In order to carry out the suggested rules, plan for an irregular border with curved lines along the sides of the yard. Do not make the border wide enough to encroach far upon the open lawn. Place the plants close enough together so that, after a few years, the individuals will be obscured in the mass effect. Put the tall shrubs in the background with the medium and low in front. Consult the Shrub Table, page 460. If the yard is narrow, it is better not to use very tall plants but arrange groupings of the medium and low. A clump in the corner running back to a few near the fence or boundary at the middle of the yard, with another clump extending toward the building, gives a very pretty effect for a small yard.

Suggested Groupings for Borders

(1, 2, and 3 are suitable for large yards only.)

1. Sumac, typhina, Dogwood, and Indian currant
2. Elder and Forsythia
3. Japan quince, honeysuckle, and white kerria
4. High bush cranberry, snowberry, and Japanese barberry
5. Spirea Van Houttei and dwarf spirea
6. Spirea Van Houttei and Japanese barberry

7. In clumps by themselves:
    Hydrangea
    Indian currant
    Honeysuckle
    Snowberry
    Sumac, Copalina
    Spice bush

Foundation planting. The chief purpose in placing shrubs and other plants close to the house is to unite the building and the grounds so that they will seem to belong together. The plan of the house should be studied before you can decide where to place the plants. There is always danger of using too many shrubs. Mass them in the angles of porches, bay windows, and steps. Allow the clumps at the corners to extend a short distance along walks or form irregular screens to obscure outbuildings. Plan for some breaks so that the foundation of the house will here and there be directly united with the grass of the lawn. Place the highest shrubs near the buildings with the lower groups next to the lawn. Choose those whose branches droop lightly and gracefully over the grass.

Suggested Groups for Foundation

1. Spirea Van Houttei and Japanese barberry
2. Honeysuckle, Morrowii, and Deutzia gracilis
3. Forsythia intermedia and low hydrangea
4. Indian currant and Deutzia gracilis
5. White kerria and dwarf spirea

Buying and planting. If you buy shrubs from a nursery, you will find that the younger, smaller plants are less expensive and give quite as satisfactory results as larger ones.

In colder portions of the country, shrubs may be set out either in the spring or fall. If the soil is moist, they will do well in the fall. Spring planting should be done as early as the ground can be worked. It should always be done before the shrubs have put out their leaves.

Rules to follow in planting:

1. After the plants are removed from the nursery grounds, keep the roots well covered and moist till you are ready to set them out.

2. Dig a round hole, large enough so that the roots may be spread out, and deep enough so that the plant may be set a little farther below the surface than it was before being removed from the ground.

3. Be sure that the soil in the lower part of the hole is rich and mellow. It is sometimes a good plan to put a few spadefuls of rich soil in the bottom of the hole.

4. Place the plant in the hole with roots spread out. Put in a few spadefuls of earth, then firm it well about the roots. This is usually done by trampling with the feet. Put in some more earth and firm again. Continue this until the hole is filled. The last three

or four inches of earth need not be firmed. The loose soil will help to conserve the moisture.

5. If the soil is dry it is a good plan to pour a pail of water into the hole; at least it should be thoroughly watered. If the soil is moist, watering is not necessary.

Care of shrubs. Stir the soil to a depth of several inches two or three times during the first two years. After that once a year is sufficient. Shrubs require little care. They should be allowed to grow naturally, hence they need little pruning. Severe pruning in the spring should be avoided. If, after a number of years, the shrubs are too thick or full, it is better to remove one or two bodily from the clump or cut out the old large branches so you will not spoil the shape of the shrubs. For a number of years it is necessary only to see that all dead wood is removed.

Hedges. While the irregular border gives an opportunity for greater variety and more artistic arrangement of plants, yet some people like to have their grounds enclosed with a shrub hedge or fence. Much work is required to keep such a hedge in good condition, for after a few years it must be trimmed at least once each season, usually two or three times. A hedge may be used between the back yard and vegetable garden, even if the border planting is used in front.

Plants for hedges. Deciduous: Japanese barberry, Berberis Thunbergii, common barberry, Amoor River privet, California privet. This last winter kills in northern and north central states.

Evergeen: Arbor vitae, Norway spruce.

Shrubs and birds. While you are making your home and school surroundings more beautiful by the use of shrubs and vines, you may at the same time provide a home for wild birds. Many birds love a shrub thicket in which to nest. By choosing shrubs that produce edible berries you may have birds coming to feed, not only during the summer, but far into the winter months. In the Shrub Table, page 460, the ones that are starred are especially attractive to birds.

2. Vines

Vines, as well as shrubs, may be used to add beauty to the home and its surroundings. Make a study of the vines that you know. Determine how they climb. How many different methods of climbing do you find? Of what advantage to plants is the climbing habit? Classify vines as to their length of life.

If you look closely at vines you find that some climb by twining their stems around supports. The morning-glory is a good example of a twiner. Others climb by little tendrils or roots which hold fast to the support, as the sweet-pea or Boston Ivy. Some

plants with tendrils also twine, as the wild grape. There are a few climbers, chiefly roses, that simply scramble over the supports.

Some vines are annuals, some perenials. Perennials are, for most purposes, more satisfactory than annuals. Annuals are grown largely for their flowers, while perennials are used for permanent screens or to decorate pillars, porches, and even the walls of buildings.

Vines may be used to advantage on any home or school grounds. You may use them to cover unsightly buildings, as old woodsheds, coal houses, etc. They may trail over the back fence and make a background for a flower border. They add both beauty and comfort when used as porch screens. In a large yard a rose arbor repays in pleasure all the work and effort required to make it a success.

Some of the most satisfactory perennials are:

Virginia Creeper or Woodbine, Ampelopsis quinquefolia.
Japanese, or Trumpet creeper, Teconia radicans.
Bitter sweet, Celastrus scadens.
Wild grape, Vitis bicolor.
Wild clematis, Clematis Virginiana and paniculata.
Wistaria, Wistaria siensis.
Illinois Rose, Rosa setigera.
Dutchman's pipe, Aristolochia macrophylla.
Green brier, Smilax rotundifolia.

For the South:
Yellow Jessamine, Gelsemium sempervirens.
Malayan Jessamine, Trachelospermum Jasminoides.

Climbing Asparagus, Asparagus plumosus.
Kudzu vine, Pueraria Thunbergiana.
Cherokee rose.
Muscadine, Vitis rotundifolia.

Annuals: Sweet pea, tall nasturtium, cypress vine, morning-glory, moonflower, cobea, canary bird vine, Balsam pear, wild cucumber, scarlet runner, velvet or banana bean.

Very pleasing effects are gained by planting a few annuals with the perennials, and allowing them to clamber up the woody stems of the hardy plants.

In planting and caring for perennial vines follow rules suggested for shrubs.

In your treatment of annuals see Planting Table, p. 474.

3. Perennial Flowers

Look in catalogs for lists of hardy perennials and decide which ones you would like to grow. Nothing can give you more pleasure than a border of perennials in your flower garden. Some of them may be started at once from seeds in the garden border, although they probably will not blossom the first year. An easy way to start perennials is to arrange a bed of rich mellow soil in a sheltered place in the garden, and sow the seeds, placing different species in rows by themselves. When the seedlings come up, thin them until they stand about three inches apart. When they are three or four inches high, transplant them to their permanent places in the border. If you

have a hotbed or green house, you may start them very early and get quicker results. You may also sow the seeds out-of-doors in the latter part of summer, treating the seedlings as suggested above. In the fall cover them with a layer of leaves or straw. In the spring they will be ready to transplant to their permanent places.

Perennials may be propagated by roots or underground stems, as well as by seeds. The underground parts are dug up and divided, and the roots set out either in the spring or fall. People who have perennials several years old are willing to divide their plants in this way. In some cases it is an advantage to the plants to dig them up and separate the accumulation of underground parts.

To make an artistic perennial border you must know the height of the plants and the color of the flowers. Group the plants to give a mass effect. Place tall ones in the rear, with clumps of medium and low in front. Mass species of the same color together. Use low plants for edgings.

List of Perennials

Tall, from 5 to 8 feet: Golden glow, Blackeyed Susan (Rudbeckia), Sunflower, Helianthus multiflorus, Rudbeckia purpurea, Rudbeckia maximia, Golden-rod, Bocconia, Hollyhock.

Medium, from 18 inches to 4 feet: Columbine, Bleeding heart, Peonies, Hardy Gaillardia, Japan Iris, Oriental Poppy, Phlox, Larkspur, Cardinal Flower, Coreopsis, Sweet William, Shasta Daisy, Crimson-eye Mallow, Pyrethum, Hardy Chrysanthemum.

Low, 6 to 12 inches: Hardy candy tuft, Forget-me-not, Ornamental grasses, Low iris, Lily of the Valley, Meadow rue, Shooting Star.

4. Annual Flowers

Material. Seeds, catalogs.

First look in your seed catalog for the plants that you know, then for others that you think you would like to grow. Consult table for colors. Do not choose many unless you are going to work a large plot of ground. If you are planning to sell flowers, choose those that are most likely to be in demand and that continue to blossom for some time. Sweet peas, pansies, asters, gladiolus, dahlia, tube roses all sell well.

If you are raising your flowers for home use, choose the ones that the family like best. It is, however, always worth while to try at least one new species.

Suggested Groups for Projects

(Those that are starred are excellent for cut flowers.)

Name	Height	Color
1. Sweet alyssum........	9 in.	White
*Cornflower or bachelor button	18 in.	Blue
2. Dwarf Nasturtium.....	12 in.	Yellow and Orange
*Gaillardia	15 to 18 in.	Yellow, Orange, Dark Red
3. Verbena	6 to 9 in.	Mixed colors
*China asters..........	18 to 24 in.	Mixed colors

(Those that are starred are excellent for cut flowers.)

4.	*California poppy......	12 in.	Yellow
	*Calendula	15 in.	Yellow
5.	Pansies	6 in.	
	*Larkspur	15 in.	Blue
6.	Portulaca	6 in.	Mixed colors
	*Sweet scabious........	15 in.	Mixed colors
7.	Dwarf marigold.......	9 in.	Shades of yellow
	Calliopsis	15 in.	Shades of yellow
8.	Dwarf coxcomb........	9 to 12 in.	Purple-red
	Tall coxcomb..........	24 to 30 in.	Purple-red
9.	Ageratum	6 to 9 in.	Blue
	Corn flower...........	18 in.	Blue
10.	Sweet alyssum........	9 in.	White
	Browallia	15 in.	Blue

The following are prettier if planted in beds by themselves: Zinnia, *Dahlia, *Cosmos, Gladiolus, Poppies, Balsam, Pinks, Petunia, Salvia.

If you are going to succeed with your flower projects, you must know something of the habits of the plants you are to grow, as well as when, where, and how to plant them. Some seeds are hardy enough to grow in cool soil and the plants are able to stand a low temperature, even a slight frost, without injury. Others must not be planted until the soil is warm and all danger of frost is past. Still others in northern states must be started indoors and transplanted when the weather is warm.

Planting Table—Annual Flowers

The numbers indicate height. No. 1 from 6 to 9 inches, No. 2, 10 to 18 inches, No. 3, 19 to 24 inches, No. 4, 27 to 30 or more inches.

Name Col	Date to Plant	Depth Inches	Distance Inches In Row	Distance Inches Of Rows
1 Ageratum, blue, white...	Indoors, Mr. 25 to Apr. 5 Garden, May 10 to 15.	¼	9	12
1 Allyssum, white.........	April 1 to 15..........	¼	9(3)	9
2 Aster, mixed............	Indoors, Mar. 22 to 29. Garden, May 5 to 12...	¼	9	12
3 Bachelor's Button, blue..	May 8 to 12...........			
3 Balsam, mixed, red, white, pink...........	May 8 to 12...........	¼	12	15
3 Blue sage, grayish, blue.	Indoors, Mar. 25 to 31. Garden, May 8 to 15...	½ ¼	12 12	18 18
1 California Poppy, yellow	April 20 to 25........	⅛	9	12
2 Calliopsis, orange, yel...	April 20 to May 5.....	¼	9	18
2 Calendula, orange, yel...	April 20 to May 5.....	¼	12	15
1 Candytuft, white........	April 15 to 30.........	¼	9	12
2 Carnation, mixed........	March 1 to April 1....	¼	9	12
4 Celosia, purplish, red....	May 1 to 10...........	¼	12	12 to 18
1 Dwarf Celosia, purple, r'd	*Indoors, Mar. 25 to Apr. 5.............	¼	9	18
1 Chinese pink, red & pink	*Indoors, Mar. 21 to 25	¼	9	12
3 Cosmos, mixed..........	*Indoors, March 25 to April 10........... Garden, May 1 to 15..	¼ ¼	18	24
—Cypress vine, red, white.	May 10 to 15..........			
2 Four o'clock, mixed.....	April 10 to 20........	½	12	18
3 Gaillardia, mixed........	April 25 to May 5.....	¼	9	15
—Gourds (vine) white.....	May 10 to 15..........	¼	Hills	2 ft. apart
4 Kochia, deep red........	Indoors, April 1 to 15. Garden, May 10 to 15.	¼	12 to 15	Hedge or Clump
3 Larkspur, mixed........	April 20 to May 10....	¼	12	18
3 Linum, blue.............	April 20 to May 10....	¼	2to4	15
2 Marigold Tall, brown, red	May 8 to 12...........	¼	9	18
1 Marigold Dwarf, brown, red, yellow............	May 8 to 12...........	¼	9	12
2 Mignonette, yellowish, brown	May 8 to 12...........	¼	12	18
4 Morning Glory vine, white, red, purple, blue	April 15 to 20.........	1	12	24
2 Nasturtium, orange, yel.	April 15 to 20.........	1	9	12
1 Pansy, purple, white, yel.	Indoors, Feb. 20 to Mr. 1 Garden, May 10 to 15..	¼	6	9
2 Petunia, purple, white, pink	May 8 to 12...........	⅛	12	18
2 Phlox, mixed...........	Indoors, Mar. 15 to 20. Garden, May 5 to 15...	¼	9	12
2 Poppy, mixed...........	April 1 to 15..........	⅛	6	12
1 Portulaca, mixed........	April 20 to 30.........	⅛	6to9	9 or 12
3 Salvia, orange, red......	Indoors, Mar. 25 to 31. Garden, May 5 to 15...	½	12	18
3 Scabiosa, mixed.........	May 10...............	¼	12	18
4 Scarlet runner, red and white	May 10...............	1	1	36
2 Snap dragon, mixed.....	Indoors, Mar. 21 to 30. Garden, May 10 to 15..	¼	12	18

*Plant in garden May 10 to 15.

Name Color	Date to Plant	Depth Inches	Distance Inches In Row	Distance Inches Of Rows
2 Stocks, mixed	May 10	¼	8	12
4 Sunflower (tall) yellow	May 10 to 15	½	15	24
3 Sunflower (dwarf) yel.	May 10 to 15	½	12	18
1 Sweet alyssum, white	April 1 to 10	¼	3	9
4 Sweet peas, mixed	April 1 to 10	4to6	2	24
2 Sweet William, red and white	Feb. 15 to May 10	¼	12	18
1 Verbena, mixed	Indoors, March 9 to 12 Garden, May 10 to 15.	¼	12	18
2 Vinca, purple, pink and white	Indoors, Mar. 28 to 31. Garden, May 10 to 15	¼	12	18
4 Wild cucumber vine, white	In Fall or Mar. 1 to 5.	1		Vine
3 Zinnia, mixed	May 8 to 12	½	12	18

Where to plant. The best place for your annuals is a plot in or near the vegetable garden. Do not make flower beds in the lawn. If you have not begun to plant shrubs around the foundation of the house, you may find a spot where asters, sweet peas, nasturtiums, and some others will do well, but this is not the best place for them. Pansies and ferns grow well around the foundation of the house.

Successful planting includes:

1. A careful preparation of the seed-bed. The soil should be fine and mellow.

2. In most cases the seeds should be planted in rows, and, if in beds, they should be elevated slightly above the garden level.

3. Do not plant the seeds very deep. A good general rule to follow is to plant a seed to the depth of four times its diameter.

4. Firm the soil well over the seeds. This may be

done with the back of the hoe, a board, or by stepping upon the rows.

5. The distance between the rows must be governed by the size of the plants. See Planting Table.

6. If you use annuals for borders in the yard or garden, be careful to plant together colors that harmonize. The height of the plants must also be considered. You can make a very pretty informal border with annuals, if you are not ready to begin the planting of shrubs and perennials. Instead of shrubs use castor beans, kochia, cosmos, tall celosia, and sunflowers.

INDEX